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Entrepreneurial Orientation and the Dynamics of Firm Growth: A System Dynamics Modelling Approach

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A System Dynamics Modelling Approach

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Abstract

Understanding how entrepreneurial processes unfold within firms is crucial to understand the heterogeneities in entrepreneurial outcomes and how firms should conduct the entrepreneurial process so as to benefit the most from it. There is no process model to depict entrepreneurship within firms in existence as yet. This study therefore investigates how entrepreneurial processes unfold within firms and what implications of how these processes are conducted will have for long term firm growth.

This study draws on the entrepreneurial orientation (EO) literature and the Penrose's theory of firm growth process to map the underlying mechanism behind the firm growth process. To capture the complexities and interactions among these sub-processes, this research employs the System Dynamics modelling method, which is most instrumental in investigating the behaviour of complex systems involving multiple interacting feedback processes.

The modelling process shows that entrepreneurial opportunity identification and entrepreneurial opportunity exploitation processes are two interlinked reinforcing processes. The simulation results further show that different EO conditions could lead to qualitatively different growth trajectories. The three EO dimensions are found to exert different influences on firm growth. An interesting and surprising finding is that marginal changes in the level of the three EO dimensions could mean big differences in the firms' long term growth trajectory. This finding on the existence of tipping point behavior for the effect of EO calls into question the tradition of understanding EO's growth contribution in a linear way.

Furthermore, an extensive number of simulation runs with different dimensional configurations of EO are performed. The simulation results show that different dimensional configurations of EO could produce different growth results and that there exist interaction effects among the three dimensions of EO on firm growth. A deep analysis of the simulation results and model structure reveals how the three dimensions interact with each other in influencing firm growth. This finding indicates that firms not only need to consider an overall level of EO, but also need to consider the specific dimensional configurations of EO.

Chapter 1. Introduction

Firm growth is the main engine behind job creation and productivity growth (Wennekers and Thurik, 1999). For small firms, growth is crucial for their survival, as they need to have established lines of business to survive the market competition. The literature has suggested many benefits of firm growth, such as the economies of scale and the economies of scope from the economic point of view (Chandler, Hikino and Chandler, 2009), and the economies of growth from the Penrose theory of firm growth (Penrose, 1959). Firm expansion is also associated with more prestige and legitimacy in industry.

Practically, firm growth potential has become a more important consideration than firm performance for financial investors. Take the second largest online retailer in China, JD.com, for example, it has been operating at huge losses for many years because of heavy expenditure on building its vast logistic network, big data, and cloud infrastructure. It also offers big price discounts in order to build up its customer base. Through these years' vast investments, JD.com is at the forefront of e-commerce supply chain management innovation. Because of these investments and developments, it has built its reputation for the fast delivery of products and is gradually taking over the market share from China's largest online retailer Alibaba. This pattern of operating at a loss to establish an advantage in long-term growth at the cost of short-term profits is not uncommon. Some big e-commerce firms like Amazon, electric car manufacturer Tesla, and the ride-hailing company Uber all place expansion to attain the dominant position for growth in the future as a priority over short-term profits.

Given that the majority of firms are profit oriented and growth will usually lead to high profit in the long term, it seems reasonable to assume that all firms are motivated to grow, sometimes even at the expense of short-term profits. However, the reality is that not every firm is willing to pursue growth (Coad, 2007). Firms often forsake opportunities for long term growth, and instead focus more on improving existing products, the rewards of which are quicker and more certain (March, 1991; Von Hippel, Thomke and Sonnack, 1999). Moreover, the common physical appearance of growth, whether it is the addition of new labour or installation of new production facilities, will result in changes in the internal structure and culture of the firm. Firm growth brings complexity to the organization, creating new organizational problems and managerial challenges, which sometimes endanger the firms' chance of survival (Greiner, 1972). Firms content with their existing profit therefore tend to refrain from further expansion. Firm growth could also be hindered by the inability to recognize new expansion opportunities, by the aversion to the risk inherent in the investment into growth, or by the increased challenge of coordination and the fear of losing control as a result of growth. Moreover, for firms that are willing to grow, there is no guarantee that they will achieve the desired growth goal. According to the UK Office for National Statistics (2018), more than 50% start-ups born in 2012 fail to survive the first five years of foundation, and even smaller percent of start-ups could develop into high growth ventures that contribute to employment. Nevertheless, there are small fractions of firms that are willing to grow, manage to survive, and eventually grow into great ventures.

1.1. Entrepreneurship and Firm Growth

Research has shown that firm growth is often associated with firm's engagement with entrepreneurial activities. Firm growth has been considered as continued entrepreneurship (Davidsson, 1991) and it is one of the primary topics in entrepreneurship research (McKelvie and Wiklund, 2010). Entrepreneurial firms are willing to innovate, to take the risks associated with new expansion opportunities, and be more proactive in terms of capturing new opportunities (Covin and Slevin, 1991). In the contemporary business context of shortening product life cycle, the entrepreneurial behaviour enables firms to constantly seek out new opportunities and to have continuous profit streams (Wiklund and Shepherd, 2005). Research also has shown that effective entrepreneurship not only enables firms to pursue new opportunities but also motivates firms to utilize existing competencies (Lisboa, Skarmeas and Lages, 2011).

Although entrepreneurship has been deemed as essential, not only by academics but also by popular press media, for firms to grow continuously in the contemporary business environment, scholar efforts, however, have not been so successful in establishing a positive relationship between entrepreneurship and firm growth. Many factors could be behind this, such as the theoretical model adopted, the measurement of core constructs, the data analysis approach employed, and whether the lagged effects on firm growth is included or not (Lyon, Lumpkin and Dess, 2000). Another often neglected but possible reason is that empirical studies normally collect data on firm growth rate at only one or two time points. The growth dynamics in between and beyond the time points are thus overlooked. While it is possible to employ longitudinal methods to investigate the dynamics of firm growth caused by entrepreneurial behaviour, to understand how firms grow and to predict future firm growth require going beyond the surface dynamics to the underlying mechanism behind the dynamics. An overwhelming number of studies have tried to understand how much firms grow (Shepherd and Wiklund, 2009), while the question of how firms grow has been ignored or taken for granted by most studies and theoretical frameworks.

1.2. How Firms Grow

In the neoclassical economic theory, firm growth simply means the increase in the output of certain products. The question of how firms grow seems irrelevant here, as the firm is assumed as a production function. Firm growth is an established line of study in industrial economics. A dominant view in the literature is that although firm growth rate could be influenced by some systematic factors related to the firm or the industrial environment, firm growth is a nearly random process (Geroski, 2005). This view attracts significant attention as studies adopting this view have successfully produced firm size distribution as found in reality. Nevertheless, the fact that human rationality and intelligence play no role in firm growth should be sufficient to render this explanation implausible. The invention of this concept "random" and the successful replication of random distributions cannot lead us to the conclusion that there really exists any process completely beyond control. As firm growth is taken as a random process under this view, the question of how firms grow seems of not very much importance.

In the business and management disciplines, a widely used theory to understand firm growth is the life stage theory. The life stage model has advanced from taking firm as a black box to firm as an organization, but the primary focus of the life stage theory has been on description of the characteristics of each stage (Greiner, 1972). The underlying mechanism behind firm growth remains obscure.

Penrose (1959) theory of firm growth process stands as an influential theory that seeks to uncover the underlying mechanism behind the firm growth process. Although published almost 60 years ago, the theory has been a widely cited theory in firm growth literature. This on one hand reflects the penetrating insights by Penrose on the phenomenon of firm growth; on the other hand, however, reflects the stagnation of theorizing in firm growth studies (McKelvie and Wiklund, 2010). According to Penrose, firm growth is driven by a bundle of underutilized firm resources and is governed by the "productive opportunity set" of the firm, i.e. all of the productive opportunities the firm could "see" and take advantage of. Entrepreneurship plays an important role in several key processes of the Penrose theory, particularly in the transition from resources to productive opportunities and then to firm growth. However, in the Penrose theory entrepreneurship is defined as the traits of the entrepreneurs and a kind of firm resource that has important influences on firm growth and that is assumed to be present in the firms the Penrose theory is concerned with. There is a lack of a process model of entrepreneurship in the Penrose theory (Baker and Nelson, 2005).

1.3. Entrepreneurial Orientation, Firm growth, and the Knowledge Gap

The existing entrepreneurship literature has used the construct of entrepreneurial orientation (EO), i.e. "the methods, practices, and decision-making styles managers use to act entrepreneurially" (Lumpkin and Dess, 1996, p. 136) to understand entrepreneurship within firms. It incorporates three dimensions – innovativeness, risk-taking, and proactiveness (Miller, 1983; Covin and Slevin, 1989) – that reflect the strategic posture of the firm with regard to entrepreneurial activities. Entrepreneurial orientation has been deemed as a growth orientation (Covin, Green and Slevin, 2006) and the principal mechanism to perpetuate growth (Eshima and Anderson, 2017). Empirical testing of the EO-firm growth relationship, however, has shown mixed results (Moreno and Casillas, 2008; Anderson and Eshima, 2013). In this situation, scholars that have been used to linear regression model try to add some moderators to see if the inconsistent results result from the differences in internal organizational processes or external environmental conditions (Wiklund and Shepherd, 2005).

In clarification of the nature of the EO construct, Lumpkin and Dess (1996) stress the distinction between the concept of entrepreneurship and the concept of EO—that the latter is used to depict the processes of entrepreneurship while the former refers to the content of entrepreneurship. While knowledge accumulation around the EO and firm performance relationship has been substantial (Rauch et al., 2009), our knowledge of the process of how entrepreneurial processes unfold within firms and how these processes lead to firm growth remain underdeveloped. There is no process-based model of EO in existence yet. This study aims to enhance our understanding in this regard by exploring how entrepreneurial processes unfold within firms and by drawing on the Penrose theory of firm growth process, this study investigates how these entrepreneurial processes lead firms into different growth trajectories.

Actually, an examination of the literature shows that there exist a good number of studies investigating EO's contribution to firm growth and there is no lack of study employing the Penrose theory of firm growth process. Nevertheless, the field of firm growth research is widely recognized to be less satisficing as a result of the stagnation in theoretical development (Nason and Wiklund, 2015) and the empirical work concluding firm growth rate as random (McKelvie and Wiklund, 2010). The problem with these studies is that they have been using static research design to investigate dynamic phenomenon and variance research design to examine process theory. It is clear from the existing studies that neither entrepreneurial process nor firm growth process unfolds linearly. The Penrose theory suggests that firm grows through a dynamic feedback process, and the recent entrepreneurship literature recognizes that entrepreneurial process as a nonlinear process complicated by recurrent patterns and contingencies. This demands a new method to study the complexity involved and the implications of these interacting processes. This study attempts to fulfill this research gap by employing the computer simulation method.

Furthermore, in the EO literature, there has been a lot of discussion on the dimensionality of EO. Studies under the unidimensional view of EO tend to examine EO as an overall construct while neglecting the specific configurations of its three dimensions (Covin and Slevin, 1989). Studies under the multidimensional view of EO investigate the individual effect of the three EO dimensions on firm growth while neglecting the joint effect of the three dimensions on firm growth (Lumpkin and Dess, 1996). It is worth noting that the collective effect of the three EO dimensions may not be the simple addition of the individual effect of the three dimensions. Whether from the unidimensional view of EO or from the multidimensional view of EO, there is no denying that there could be interaction effects among the three dimensions. Yet it is unclear if these interactions exist, how would these interactions alter the outcomes in firm growth, and what are the mechanisms behind their interactions.

The examination of the interaction effects of the three EO dimensions then leads to a question of is there a best dimensional configuration of EO for firm growth in existence? Undeniably, the entrepreneurial process is featured by risks and shaped by random events. This on one hand may signal that entrepreneurial process is uncontrollable; on the other hand, however, the notion of the entrepreneurial process unfolding not in a universal way offers the scope for a design science of entrepreneurship (Dimov, 2016). Can we "design" the entrepreneurial process so that firms could benefit the most from it?

1.4. Research Questions and Potential Contributions

Specifically, this study aims to investigate the following research questions:

Firstly, how does entrepreneurial process unfold within firms? And how does the entrepreneurial process interact with other organizational processes to lead to firm growth?

Secondly, how does EO affect firm growth?

Thirdly, is there any interaction effect among the three dimensions of EO in influencing firm growth? And what is the underlying mechanism behind the interaction effect?

Lastly, is there a dimensional configuration of EO that is best for firm growth?

In answering these questions, this study aims to contribute to the existing literature in the following ways. Firstly, this study aims to develop an entrepreneurial process model to shed light on how entrepreneurial processes unfold within firms. While there is wide recognition of the stages of the entrepreneurial process, how these sub-processes interact and their dynamical implications for firm growth and for the evolution of the entrepreneurial process itself have received insufficient attention. Employing the simulation method, this study captures the dynamic feedback structure involved in the entrepreneurial process and illuminates how to conduct the entrepreneurial process so as to attain desirable firm growth outcomes.

Secondly, empirical studies examining EO and firm growth relation use either cross-sectional research design or use data of firm growth at two time points. The dynamics of firm growth caused by EO thus have been ignored. These dynamics have important implications for firms to understand the true effect of EO and to make entrepreneurial policy. Things could go better before going worse or go worse before going better. EO explicitly is not a theoretical construct that is meant to explain firm growth at only a few static time points. By doing so, these studies also have the assumption that firms grow in a linear way, which in reality more often is not the case.

Thirdly, the long-lasting and unsettled discussion on the dimensionality of EO has been mainly made under the assumption of research using the variance based approach (McMullen and Dimov, 2013). Will new insights be gained on the nature of the EO construct through specifying EO in process terms, and if there is, what would the new insights be? This could also deepen our understanding of the distinction and complement between variance approach and process approach of entrepreneurship research.

1.5. Thesis Structure

This study is organized as follows: The literature review part explains the origin and nature of the EO concept, the current discussion on its dimensionality, and reviews the existing literature on EO and firm growth relationship. This part also explains the differences between the process approach and the variance approach, as well as presents a review of the firm growth literature. This includes the firm growth studies under the different theoretical lens and an elaboration of the Penrose theory of firm growth process. After that, the research method part explains the basics and principles of the System Dynamics simulation method. This is followed by the model structure part, which explains how the system dynamics model in this study is developed based on the combination of EO literature and Penrose's theory of firm growth process. Following that, extensive simulations are conducted to examine the individual effect of three EO dimensions as well as their joint effects on firm growth. By tracing model behaviour down to model structure, this study then analyses the process mechanisms behind the effects of EO on firm growth, as well as the mechanism behind the interaction effects among the three dimensions of EO. This thesis ends with a discussion of its theoretical and managerial implications, as well as some limitations of this study and recommendations for future research.

Chapter 2. Literature Review

2.1. Entrepreneurship and Entrepreneurship within Firms

The scholarly field of entrepreneurship seeks to “understand how opportunities to bring into existence future goods and services are discovered, created, and exploited, by whom, and with what consequences” (Venkataraman, 1997, p. 120). A key implication of entrepreneurship is the change and occurrence of new combinations in the society and economy. This assumption, however, is incompatible with equilibrium conditions assumed in the neoclassical microeconomic theory, which emphasizes doing better on what already exists. Entrepreneurship, along with other factors like war, climate, and politics, is in economic models taken as external forces that economists acknowledge the existence but avoid analysing. The existence of entrepreneurial opportunities and the field of entrepreneurship rest on some premises about the economy and society.

The first premise, also called the weak premise of entrepreneurship, is based on the work of Kirzner (1997). Kirzner seeks to understand how the market approaches equilibrium from non-equilibrium status, as ignored by the mainstream neo-classical economic models. The way he approaches this problem is through the entrepreneurial discovery perspective. Kirzner posits that earlier entrepreneurial errors create profit opportunities that are discovered by alert entrepreneurs. Through this entrepreneurial discovery process, market participants gradually acquire more mutual information, thereby pushing the market towards the equilibrium direction.

The second premise, also called the strong premise of entrepreneurship, comes from the “process of creative destruction” by Schumpeter. Schumpeter (1942) recognizes capitalism as an evolutionary process and “the impulse that sets and keeps the capitalist engine in motion comes from the new consumers’ goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates”. These new things “incessantly revolutionize the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of creative destruction is the essential fact about capitalism” (p. 83). He points out that the question that has been looked upon is how capitalism administers the existing structure while the real question is how the structure is created and destroyed. Under this creative destruction view, even if the economy reaches the equilibrium condition, it will only be temporary–entrepreneurship will disrupt the equilibrium and break new grounds for economic growth through radically new resource recombinations.

After a handful of arguments on why price does not contain all information (Eckhardt and Shane, 2003), and thus cannot govern the allocation of resources, entrepreneurship scholars have sought to understand why and how new combinations of resources come into place. Since the publication of Shane and Venkataraman (2000), the concept of entrepreneurial opportunities, i.e. " those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production" (Casson, 1982), has become central to entrepreneurship research and created new research ground in this field. This results in a research shift from the prior person-centric approach that entrepreneurship is based on certain attributes of the agents to the opportunity-person nexus perspective that argues entrepreneurship theory should be based on the interplay between opportunities and the actions of the agents (Eckhardt and Shane, 2003).

The more traditional understanding of entrepreneurship lies in the creation of a new venture by an entrepreneur or by a team of people (Gartner, 1985). The core nature of entrepreneurship is the emergence of new economic activities, which should not be limited to be only in the form of new venture creation (Davidsson, 2003; Davidsson and Wiklund, 2007). Entrepreneurship could also happen within established firms (Hoskisson et al., 2011). Actually, established firms are actually in a better position to engage with entrepreneurship as they possess more knowledge and resources (Schumpeter, 1942; Shane and Venkataraman, 2000). 3M Corporation, for example, is well known for being an entrepreneurial company and has been awarded the highest innovation award by the US government. It allows its employees to spend 15% work time on unproven projects and provides resources to support the experimentation of new ideas. The constant search and pursuit of new opportunities bring the firm sustained growth. Entrepreneurship is also a salient characteristic of many very successful firms, such as Apple, Google, Intel, IBM, General Electric Company, Marks and Spencer. The engagement with entrepreneurship enables these firms to develop new revenue streams as opportunities for new value-creating innovations are identified and exploited.

The influx of entrepreneurship into the study of large and established firms arouses the interests of management scholars to apply existing theoretical approaches. For example, the popular resource-based theory in strategic management research has been widely applied to entrepreneurship research. Entrepreneurial actions also enable firms to achieve competitive advantage in the market place through recombining and reconfiguring the unique bundle of firm resources (Alvarez and Busenitz, 2001; Yiu and Lau, 2008). However, the benefits of entrepreneurship do not come with certainty and firms face unique challenges when deciding to engage with entrepreneurship. Entrepreneurial activities face the impediment from the established operations of a firm, especially the successful operations (Drucker, 2014). Entrepreneurship brings financial returns that are uncertain and distant and have to compete with exploitation activities that bring certain and quick financial payoff for the limited firm resources.

Firms therefore are inclined more towards incremental improvements of existing products and services than developing new breakthrough innovations (March, 1991). With the extraordinary success of firms like Apple and 3M comes the painful failure of thousands of other firms that try to be entrepreneurial and to grow (Stevenson and Jarillo, 1990). This raises the academic interest in the true relationship between entrepreneurship and firm growth, and how should firms engage with entrepreneurship so as to benefit from it.

To figure out the true relationship between entrepreneurship within firms and firm growth entails the introduction of a new concept to describe and explain the phenomenon of entrepreneurship within firms, as well as entails the consideration of some organizational level factors, such as organizational structure, strategy, resources, culture, and so on (Wiklund, 1999; Zahra, Neubaum and Huse, 2000). Several constructs, like corporate entrepreneurship (Covin and Miles, 1999), corporate entrepreneurship strategy (Ireland, Covin and Kuratko, 2009), strategic entrepreneurship (Schindehutte and Morris, 2009), entrepreneurial orientation (Lumpkin and Dess, 1996), and entrepreneurial management (Stevenson and Jarillo, 1990), are in existence to serve the study of entrepreneurship at the firm level.

The phenomenon domain of corporate entrepreneurship varies across the studies, but with innovation, internal corporate venturing, and strategic renewal being the common phenomenon of corporate entrepreneurship (Zahra, 1993; Teng, 2007). Some studies under the corporate entrepreneurship domain try to ascertain the causes and effects of these forms of corporate entrepreneurship (Ling et al., 2008; Yiu and Lau, 2008; Wei and Ling, 2015). The early concept of entrepreneurial management proposed by Stevenson and Jarillo (1990) is aimed to establish or to clarify the link between entrepreneurship and corporate management, as the two were deemed as contradictory. Using the concept of corporate entrepreneurship strategy, Ireland, Covin and Kuratko (2009) suggest that entrepreneurship could be pursued as a unique and identifiable firm strategy, the intent of which is to leverage entrepreneurial opportunities to rejuvenate the firm and to achieve growth. The literature defines the concept of entrepreneurial orientation in terms of the behavioural dimensions of entrepreneurship. The recurring innovative, risk-taking and proactive firm behaviour is evidence to infer the presence of an entrepreneurial orientation. Although the concept of entrepreneurial orientation has its roots in the strategy making literature, the existing literature of EO tends to study strategy as separate from EO. For example, in the conceptual framework proposed in Lumpkin and Dess (1996), strategy is a moderator of the EO and firm performance relation. Moreno and Casillas (2008) investigate firm strategy as an intermediate variable between the EO and firm growth relation.

While the diversity of these constructs may enable us to capture different specific aspect of entrepreneurship within firms, it comes at the cost of creating confusion on what phenomenon each construct refers to and what are the boundaries among these constructs. As these concepts intertwine and sometimes get interchangeably used, the focal phenomenon even under the same conceptual label are often undefined and inconsistent (Sharma and Chrisman, 1997; Corbett et al., 2013). Despite the ongoing discussion on the nuances of the different concepts, the concept of entrepreneurial opportunity remains central to entrepreneurship within firms and the nature of the entrepreneurial process, i.e. the identification and exploitation of opportunities for new resource recombination, still applies (Morris, Kuratko and Covin, 2010).

The focus of this thesis is on the construct of entrepreneurial orientation (EO). Entrepreneurial orientation refers to the methods, practices, decision-making styles that managers use to act entrepreneurially (Lumpkin and Dess, 1996). EO has been recognized as a “strategic posture” of the firm. In this paper, a “strategic posture” is broadly defined as a firm’s overall competitive orientation and that it is argued that the three dimensions comprise an overall unidimensional strategic orientation. Despite being subject to some ongoing discussions on the nature and measurement of this construct, EO has become a key construct in the study of entrepreneurship at the firm level (Covin and Lumpkin, 2011). This study adopts the EO concept to investigate entrepreneurship within firms for the following reasons:

The first reason for the prevalent use of EO construct is that this concept enables us to measure the degree of entrepreneurship of a firm and to distinguish entrepreneurial firms from conservative firms through the extent to which firms innovate, take risks, and act proactively (Covin and Lumpkin, 2011; Anderson et al., 2015). For long entrepreneurship scholars have pondered upon what it means for a firm to be entrepreneurial. The challenges in establishing the criteria according to which to label a firm as entrepreneurial and to determine its degree of entrepreneurship lie not only in finding out the commonalities across the various neither alternative nor exclusive forms of entrepreneurial phenomenon that may concurrently exist within firms and integrating the disparate parts of firms involved in these activities to the overall firm level, i.e. it is the firm as a whole that acts in entrepreneurial manners, but also in the inconsistencies between attitudes and behaviour, between efforts and outcomes, and in the various sometimes conflicting organizational consequences (Covin and Miles, 1999). Depicting entrepreneurship from multiple behavioural dimensions that underlie the different forms of entrepreneurial phenomenon within the firms effectively evades these inconsistencies.

Secondly, EO is a concept originally intended to depict entrepreneurial processes within firms. As noted in Van de Ven and Engleman (2004), the vast majority of entrepreneurship research has focused on answering the variance approach related question "what are the antecedents and consequences of entrepreneurship?" instead of the process related question "how does the entrepreneurial process unfold over time?". The concept of EO is meant to distinguish itself from other concepts by providing a framework for understanding entrepreneurial processes within established firms. Although EO scholars have yet fulfilled this intention, the EO concept is meant to depict the entrepreneurial processes within firms.

Thirdly, the EO concept explicitly depicts the entrepreneurial process as a multidimensional phenomenon. As a strategic orientation, EO shapes how firms make sense of the environment, how to make use of firm resources and restructure value chain activities. Lastly, as a strategic posture, the concept of EO explicitly points to entrepreneurship as an organizational phenomenon pervading throughout all levels of the firm (Wales, Monsen and McKelvie, 2011) and implicitly influences the strategy making process of the firm, although the firm does not necessarily need to change its strategy in order to be entrepreneurial. As an "orientation", EO represents a natural and long-lasting behavioural inclination. This distinguishes entrepreneurship from sole innovation by a specific organizational unit or an occasional exhibition of entrepreneurial behaviour by the firm.

2.2. Entrepreneurial Orientation

2.2.1. The Origin and Nature of the Concept

The concept of EO has its root in the literature of the strategy making process, which is viewed as patterns of actions or decision making styles that are generalizable across firms (Dess and Lumpkin, 2005). Mintzberg (1973) comes up with three distinct modes of strategy making process, of which the entrepreneurial mode of strategy making could be regarded as the embryo of EO. Strategy making process in the entrepreneurial mode is characterized by the active search for opportunities, bold actions in the face of uncertainty, the power controlled by one strong leader, and with the dominant goal being achieving sustained growth. These characteristics reflect some of the meanings of the commonly used three EO dimensions. Under this explanation, Mintzberg further suggests that certain conditions of the organization and its environment must be met for a firm to favour one mode of strategy making over the others. Miller and Friesen (1978) identify eleven dimensions of strategy making process, in which innovativeness, proactiveness, and risk-taking are included.

EO also resembles the prospector firms in Miles et al. (1978). Miles et al. (1978) develop a model about how organizations adapt to environment and uncertainty by observing the behavioural patterns of firms. Firms in the strategic typology of prospectors succeed due to constantly looking for and exploiting new product and market opportunities. They are willing to engage with constant innovation in product or market development, even at the expense of short-term profitability and overextension of firm resources.

The move from the characteristics of a certain mode of strategy making process to the process of entrepreneurship at the firm level is made by Miller (1983), although the concept of EO does not appear. The entrepreneurial firm is defined as "one that engages in product-market innovation, undertakes somewhat risky ventures, and is first to come up with proactive innovations, beating competitors to the punch", while non-entrepreneurial firms are those that "innovate very little, highly risk averse, and imitate the competitors instead of leading the way" (Miller, 1983, p. 771). Miller further suggests that entrepreneurship at the firm level could be tentatively viewed as a composite weighting of these three variables.

Drawing on the work of Mintzberg (1973) on three modes of strategy making, Miller classifies firms into three categories, that is, the simple, planning, and adaptive firm, and explores the determinants of entrepreneurship respectively in these three types of firms. Another contribution of Miller (1983) is that it shifts the emphasis in the literature from identifying entrepreneurship with a personality of the chief manager to the entrepreneurial activities of the firm. The argument behind this move is that the entrepreneurial role performed by individuals could also be performed by an established entire organization.

The concept of EO makes a formal appearance in Covin and Slevin (1989). This paper seeks to understand how small firms' strategic posture and organizational structure influence their performance in benign and hostile environmental conditions. The firm's entrepreneurial strategic orientation, which is characterized by "frequent and extensive technological and product innovation, an aggressive competitive orientation, and a strong risk-taking propensity by top management" is used as indicative of firms' strategic posture (Covin and Slevin, 1989, p. 79). This paper also develops the so far most used nine-item measure of EO construct based on the scale of EO developed in Miller (1983).

Lumpkin and Dess (1996) make further clarification on the meanings of the different dimensions of EO and propose the contingency framework to investigate the EO and firm performance relationship. Entrepreneurial orientation in Lumpkin and Dess (1996, p. 136) is defined as "the methods, practices, and decision-making styles managers use to act entrepreneurially". They make a clear distinction between the concept of EO and that of entrepreneurship, in that EO represents the process of entrepreneurship while the latter refers to the content of entrepreneurship. They propose a five-dimension model of EO, including innovativeness, risk-taking, proactiveness, and competitive aggressiveness, to characterize and distinguish key entrepreneurial processes within firms.

Innovativeness refers to firms' willingness to experiment with new ideas, creative processes and R&D that may result in new products, processes, or services. Innovation has been regarded as a key element of entrepreneurship (Covin and Miles, 1999). Innovation motivates firms to address problems in a novel way, to expand firms' productive opportunity set (Penrose, 1959) and to create new sources of profit stream.

Risk-taking refers to the degree to which firms are willing to make large and risky resource commitments into projects with uncertain returns. High risk-taking firms invest significant firm resources into unexplored new projects in the interest of obtaining high financial return (Dess and Lumpkin, 2005). Because entrepreneurship always involves new and unknown things, risk has been a defining characteristic of entrepreneurial process that firms usually cannot know the outcomes of their actions for sure. Although both gambling and risk-taking involve chances and probabilities, there are essential differences between the two. Successful entrepreneurs take risks by collecting information and carefully understanding the likelihood of different outcomes. Extant literature largely assumes a positive relationship between risk-taking and firm performance, because the majority of entrepreneurial opportunities contain risk and only by taking risks can firms transform opportunities into its competitive advantage. Actually, it is the risks inherent that preclude the dissipation of opportunity and cause the opportunity window to exist.

Proactiveness refers to an opportunity seeking and forward-looking perspective that induces the anticipation and seizing of new opportunities quickly ahead of the competition (Lumpkin and Dess, 1996). The purpose of being proactive is to take advantage of the first mover advantage in the short term and to establish a technological leadership position in the long term. Creating a new product or market domain that others have not recognized or hesitate to pursue gives firms the advantage to establish industry structure and standard. Proactive firms are more attentive to changes and trends in the market, which embeds potential opportunities to refresh the business. Through constantly monitoring the environment and preparing for changes, proactive firms can take quick action when opportunities emerge. Proactive firms are therefore likely to have superior performance as they act proactively to understand the customers and market changes rather than passively following the trends (Hughes and Morgan, 2007).

Lumpkin and Dess (1996) add two extra dimensions of aggressiveness and autonomy into the EO construct. Autonomy refers to "the independent action of an individual or a team in bringing forth an idea or a vision and carrying it through to completion" (Lumpkin and Dess, 1996, p. 140). As opposed to entrepreneurial initiatives led by the centralized vision and a strong leader of the firm, this dimension stresses the freedom granted to the individuals across all levels of the firm to exercise creativity and to pursue new opportunities (Lumpkin and Dess, 1996). This autonomous entrepreneurial spirit and freedom are unlikely to be extinguished by factors such as resource availability or environmental threats. Competitive aggressiveness refers to "firm's propensity to directly and intensely challenge its competitors to achieve entry or improve position, that is, to outperform industry rivals in the marketplace" (Lumpkin and Dess, 1996, p. 148). A distinction is made between competitive aggressiveness and proactiveness by Lumpkin and Dess (2001) in that proactiveness refers to how firms relate to opportunities, while competitive aggressiveness refers to how firms respond to the competitive threat. To be consistent with the majority of the existing research, this dissertation considers EO to encompass three dimensions: innovativeness, proactiveness, and risk-taking.

While the strategy making literature provides the sources and skeletons of the EO concept, as the entrepreneurship study evolves into an important discipline itself, it seems imperative to make a distinction between EO and the strategy related concepts. Although EO has been deemed as a strategic orientation (Covin and Slevin, 1991), which is defined as a firm's overall competitive orientation (Covin and Slevin, 1989), strategy is a factor that has been considered separate from EO (Lumpkin and Dess, 1996; Ireland, Covin and Kuratko, 2009). To be entrepreneurial firms need not change their strategies (Covin and Miles, 1999).

An ongoing discussion on the nature of the EO construct relates to whether EO is a dispositional or a behavioural construct. As a dispositional construct, EO represents firms' disposition to engage in behaviours that are risk-taking, proactive, and innovative. In contrast, as a behavioural construct, EO represents firm behaviours that possess the characteristics of innovativeness, proactiveness and being risk-taking.

Covin and Slevin (1991, p. 7) apply a firm behaviour perspective to entrepreneurship and argue that “organizations with entrepreneurial postures are those in which particular behavioural patterns are recurring. These patterns pervade the organization at all levels and reflect the top managers’ overall strategic philosophy on effective management practice”. They stress the advantages of adopting a behaviour perspective towards entrepreneurship. Firstly, behaviour and actions are the essential ingredients and what gives meaning to the entrepreneurial process. Non-behavioural attributes do not make a firm entrepreneurial. Just as we judge one as being an entrepreneur or not according to his/her actions—not his/her psychological profile, we judge a firm as being entrepreneurial or not according to its behaviour—not the attitude or characteristics of the managers. Possessing a disposition to engage with a kind of behaviour cannot guarantee the behaviour will be conducted in the end. Secondly, a behavioural perspective facilitates the measurement of firms’ entrepreneurial level, because behaviour could be directly observed and measured. Lastly, taking EO as a dispositional construct makes it hard to distinguish EO from other intangible firm attributes, such as entrepreneurial culture (Fayolle, Basso and Bouchard, 2010).

The discussion may originate from the Covin and Slevin (1989) measure of EO incorporating both behavioural and dispositional items. While a few scholars take the stance that EO could represent both dispositional and behavioural phenomenon (Anderson et al., 2015), some argue that a theoretical construct could be either but cannot be both (Covin and Lumpkin, 2011).

This paper inclines towards the EO as a behavioural construct perspective, because as Covin and Slevin (1991) suggest, it is behaviour rather than the attitude that gives meaning to the entrepreneurial process. A firm cannot be deemed as entrepreneurial just because it has the “wish” to conduct entrepreneurial activities. Not all disposition will result in corresponding behaviour. Nonetheless, it is reasonable to conceive an association between disposition towards entrepreneurship and entrepreneurial behaviour, because when a certain behavioural pattern repeats over time, it will sooner or later translate into a disposition. With this then comes another point on the nature of EO. That is, EO implies some extent of temporal stability with regard to firms’ entrepreneurial behaviour. A firm that only occasionally engages with the entrepreneurial act cannot be recognized as entrepreneurial. Only when a firm's entrepreneurial behaviour is on a sustained basis shall we infer the existence of EO for this firm (Covin and Lumpkin, 2011).

2.2.2. The Dimensionality of EO

There are two ways to measure a latent construct: the reflective measure and the formative measure. A lot of discussion on EO centers on whether EO is a reflective or a formative construct. Under the reflective view, EO is a latent variable that acts as the common cause of changes in its three dimensional indicators and the three dimensions are behavioural manifestations of an overall entrepreneurial strategic posture. The causal flow is from EO to its three dimensional indicators. As EO is the common cause behind the three dimensions, the three dimensions must be correlated. Under this view, any change in EO will result in changes in each of its three dimensions such that they reflect the higher order latent construct. Therefore, the three dimensions are also supposed to co-vary. However, the change in any of the three dimensions has no effect on the higher order EO. Furthermore, as EO induces changes in its sub-dimensions, if EO exists, the three dimensions therefore will be all present. Interpreting this in another way, if any of the three dimensions is absent, then we could conclude that EO does not exist. This view is consistent with Miller (1983) and Covin and Slevin (1991) argument that firms should exhibit all three dimensional behaviour simultaneously in order to be entrepreneurial. In Covin and Slevin (1991, p. 7):

> "In general, theorists would not call a firm entrepreneurial if it changed its technology or product line simply by directly imitating competitors while refusing to take any risks. Some proactiveness would be essential as well. By the same token, risk-taking firms that are highly levered financially are not necessarily considered entrepreneurial. They must also engage in product-market or technological innovation."

Studies adopting this reflective view generally use the scale developed by Covin and Slevin (1989). However, empirical operationalization of this construct in existing research differs. Some studies adopt the structural equation model (Lisboa, Skarmeas and Lages, 2011; Patel et al., 2015), while others derive a summated value of EO, i.e.

taking the mean of the different indicators, and use regression model for the analysis (Wales et al., 2013; Engelen et al., 2014).

Under this unidimensional conceptualization, EO refers to the shared variance among the three dimensions. When theorizing causal relationships between EO and other factors, the argument, therefore, should be based on the coexistence of the three dimensions and focus on the shared variance of the three dimensions, rather than the individual dimensions. Many of the existing studies, however, do not satisfy this condition. This conceptualization also implies that the three dimensions of EO should share common antecedents and consequences (here common does not mean “the same”).

Variances generated by the three dimensions include common variance shared by all three dimensions, variance shared by only two dimensions, the variance that is unique to one specific dimension, and the random variance. Under the reflective measurement model, only the variance commonly shared by the three dimensions is attributed to the EO construct. This comes to one major disadvantage of this reflective measurement model-it cannot shed light on the individual effect of the three dimensions.

Under the formative view, the causal flows are from the three dimension indicators to the EO. EO is the result of the combination of its dimensions, rather than the cause behind its dimensions. Changes in any of the three dimensions will result in changes in EO. Under the multidimensional view, the dimensions are free to vary independently or to correlate with each other. Conceptually, the meaning of EO is derived from the configuration of its sub-dimensions. And that the three dimensions do not need to share common antecedents or consequences.

This view is consistent with the conceptualization of EO in Lumpkin and Dess (1996) that the five dimensions of EO could vary independently and that firms with any effective combinations of the dimensions could be called entrepreneurial firms. As EO is a theoretically derived construct, there is no empirical ground that could deny the combination of the dimensions. Lumpkin further argues that firms may rely differently on the dimensions for better performance. Examples given are Sony, which is characterized by proactive and bold market entry with innovative products, and Matsushita, which is characterized by imitation, but being proactive in market entry and risky in terms of heavy investment into manufacturing and marketing. Although firms that undertake a new business that has been done by many others are not innovating, they are taking risks as they are investing heavily in the business.

This formative measure of EO also finds some empirical support. Using confirmatory factor analysis on survey data from health care executives, Stetz et al. (2000) find that the dimensions of EO are independent and that the formative construct has more explanatory power in explaining the variance in firm growth than when EO is taken as a reflective construct.

Under the formative view, variance in the EO construct includes not only the commonly shared variance among the three dimensions but also the variance shared by any two dimensions and by any one individual dimension. Studies adopting this multidimensional view typically investigate the individual effect of each dimension of EO. Although Rauch et al. (2009) find that the three dimensions of EO are equally important in determining firm performance, there are also findings showing that the three dimensions of EO not always producing consistent effects on firm performance. As the first to examine the five dimension framework of Lumpkin and Dess (1996), Hughes and Morgan (2007) find that in young incubating firms proactiveness and innovativeness are the primary dimensions that contribute positively to firm performance. They also find that risk-taking has a negative influence on firm performance, while autonomy and competitive aggressiveness do not produce any significant influence on firm performance. A study by Moreno and Casillas (2008) explicitly supports the multidimensional view. They also find that the weight of the innovativeness dimension is higher than the weights of proactiveness and risk-taking dimensions in the explanation of firm growth. Shan, Song and Ju (2016) find that innovativeness increases innovation speed, while risk-taking reduces innovation speed.

As this stream of literature sheds lights on the individual effect of the three dimensions of EO on firm performance, the interaction effects among the three dimensions are neglected. The effect of one dimension is usually examined using regression analysis, when the other dimensions are held as constant. As the three dimensions of EO are likely to covary, the combined effect of the three dimensions, i.e. the overall effect of EO, is unlikely to be the additive of the individual dimensional effects.

There also exists the “best of both worlds” view, which argues that examining both the overall EO construct and the independent effects of each dimension will be best for knowledge accumulation (Wales, 2015). This study adopts the stance that it would gain more insights to analyse both the overall EO construct and the independent effects of the three dimensions.

Lomberg et al. (2016) distinguish the independent effect and collective effect of EO dimensions on firm performance and explore how the bilaterally shared effects among any two of the three dimensions influence firm performance. A thing to note is that what they investigate is how the effect of change in one dimension of EO on firm performance is conditioned on the simultaneous change in the other dimensions of EO, not how the effect of one dimension of EO is dependent on the level of the other dimensions. This investigation, therefore, has the assumption that the three EO dimensions must be correlated. They find that while EO significantly influences firm performance, only proactiveness has a significant individual effect on firm performance when the two other dimensions are controlled. This finding leads them to conclude that there exist significant commonly shared effects among the three EO dimensions. The largest shared effect as discovered by them is the bilaterally shared effect between innovativeness and proactiveness. They also find that in the high-tech industry, risk-taking, when not aligned with innovativeness or proactiveness, has a detrimental effect on firm performance. To the knowledge of the author of this study, their paper is the first to investigate the individual as well as the bilaterally shared variance among the three dimensions of EO. However, the variance shared among the three dimensions is not included in the analysis.

2.3. Entrepreneurial Orientation and Firm Growth

EO scholars have committed significant efforts to understand the EO and firm performance relationship, both conceptually and empirically. These studies usually adopt the contingency framework, which argues that the causal relationship is context specific. Various external environmental and internal organizational variables have been examined as moderators between the EO and firm performance relation (Stam and Elfring, 2008; De Clercq, Dimov and Thongpapanl, 2010; Lisboa, Skarmeas and Lages, 2011; Wales et al., 2013). To review and summarize these different studies, Rauch et al. (2009) have conducted a meta-analysis of existing studies on EO and firm performance. Their analysis finds a positive relationship between EO and firm performance with the magnitude of the effect being around 0.242. They also find this effect is robust to different contexts and different operationalization of the EO constructs.

Nevertheless, there are some other eye-catching findings. Some scholars argue that the benefit of EO may be subject to marginal diminishing effect. Tang et al. (2008) find that in the context of China, the relationship between EO and firm performance is inverted U shaped. They argue that a moderate level of EO will lead to best firm performance as firms with low EO cannot compete effectively, while firms with high EO lack the institutional and organizational support for highly risky and innovative projects in the context of China. Similarly, Wales et al. (2013) find that in the resource-constrained context, increasing EO only leads to beneficial performance to a point, after which small firms are likely to get below zero returns from the dramatic and risky innovations incurred from a high level of EO.

Another emerging line of argument on the EO-performance relationship is that EO may also lead to firm failure—considering that the studies with findings on positive EO-firm performance relationship have the problem of survival bias. Drawing on the distinction between exploration and exploitation activities in organizational learning theory, Wiklund and Shepherd (2011) argue that EO motivates firms to pursue exploratory projects that are distant from the firm's competencies. These projects bring highly uncertain outcomes. EO therefore will lead to an increase in the variance of firm performance, rather than causing an increase in the mean performance of firms. To test this hypothesis, they include both firm performance and firm failure as the dependent variables in their analysis. Their findings show that EO enhances both firm performance and firm failure. Following this view, Patel et al. (2015) study how absorptive capacity could manage this downside of EO.

Some studies have paid attention to the temporal considerations in the EO-performance relationship. Employing multiple regression analysis to analyze data on a sample of Swedish small firms, Wiklund (1999) finds a positive relation between EO and firm performance and that this relationship is stronger in the second year of firm performance, as compared with the first year performance. This result leads to the conclusion that EO is not a strategic orientation that will only lead to a temporary increase in firm performance, but that its effect could extend over a period of time.

EO has also been theorized to contribute to other firm-level outcomes, like strategic learning capability (Anderson, Covin and Slevin, 2009), innovation speed (Clausen and Korneliussen, 2012; Shan, Song and Ju, 2016), and innovation capability (Lisboa, Skarmeas and Lages, 2011; Pérez-Luño, Wiklund and Cabrera, 2011). DiVito and Bohnsack (2017) adopt the multidimensional view of EO and use an exploratory, mixed method to study a sample of 24 firms in the sustainable fashion sector. Their data reveals three types of sustainability decision-making profiles, which correspond to different dimensional configurations of EO. There are also studies investigating the antecedents of EO (Green, Covin and Slevin, 2008; Cao, Simsek and Jansen, 2012; De Clercq, Dimov and Thongpapanl, 2013; Rosenbusch, Rauch and Bausch, 2013).

EO has been widely considered as a growth orientation (Lumpkin and Dess, 1996; Covin, Green and Slevin, 2006; Moreno and Casillas, 2008). In Mintzberg (1973), the entrepreneurial model of strategy making process is characterized by strong growth orientation. Theoretically, EO could promote long-term firm growth by identifying and exploiting entrepreneurial opportunities with potentially great returns (Lumpkin and Dess, 1996). Firms stay ahead of the competition through constant innovation and as first movers they have the advantage of establishing industry standards and dominating distribution channels (Wiklund, 1999). Entrepreneurial firms typically emphasize research and development and always occupy a leadership position in technology. Therefore, it seems intuitive that entrepreneurially oriented firms would grow faster than more conservative firms.

As an important measure of firm performance, firm growth has been mainly investigated as one of the indicators of firm performance (Stam and Elfring, 2008) and has received limited attention by itself (Wiklund and Shepherd, 2005). Studies tend to incorporate firm growth-related indicators, such as sales growth, employment growth, assets growth and firm profitability related indicators, such as gross profits and net profits margin, to form an overall measure of firm performance (Wiklund and Shepherd, 2003; De Clercq, Dimov and Thongpapanl, 2010; Eshima and Anderson, 2017). However, firm growth does not always correlate positively with other firm performance measures, because to pursue long term firm growth requires reinvesting firm revenue into new enterprising activities (Moreno and Casillas, 2008).

Covin, Green and Slevin (2006) find a positive relationship between EO and firm sales growth rate, and they find that this relationship is stronger for firms with autocratic decision-making style and emergent strategy formation process. Adopting the resource-based view, Anderson and Eshima (2013) employ a configurational model to investigate the three-way interaction effects among firm age, intangible resources, and EO on firm growth rate. Their analysis shows that the relationship between EO and firm growth is strongest among SMEs that are younger and possess a higher stock of intangible resources. Using Partial Least Squares method, the study by Moreno and Casillas (2008) reveals that EO and firm growth is positively related and this relation is positively enhanced by the availability of unused firm resources.

A widely applied theoretical perspective in the EO studies is the resource-based view (RBV). The main argument of RBV is that firms in possession of valuable and rare resources could achieve better performance if these resources are also inimitable as well as non-substitutable (Barney, 1991). Studies on EO-firm performance relationship and EO-firm growth relationship adopting the resource-based view share similar theoretical arguments. That is, the process of opportunity identification and exploitation require significant firm resource commitments. Therefore, an EO would not be effective to promote firm growth without resources (Wiklund and Shepherd, 2005). Likewise, resources will not be useful for growth if they are not leveraged into opportunity pursuit for growth (Wiklund and Shepherd, 2003).

The above studies show empirical evidence that EO does affect firm growth and that the resource-based theory provides as a good framework to understand the EO and firm growth relationship. However, the dynamics of firm growth generated by adopting EO remain unclear—due to the difficulty in obtaining panel data, existing studies only measure growth at a maximum of two time points. However, in reality firms are unlikely to grow in a linear way. The interesting dynamics in between and beyond the two time points are neglected. Upon adopting a new policy, things can go better before going worse or go worse before going better. It is possible that the different time intervals used lead to different results regarding EO and firm growth relationship. This study takes the stance that to truly understand the contributions of EO to firm growth, we need to understand the long-term growth patterns and dynamics generated by adopting an entrepreneurial orientation. Just as Ployhart and Vandenberg (2010) comment, it is difficult to say that any theory aims only to explain a phenomenon at a single time point. By eliciting the underlying generative mechanism behind firm growth process, this study seeks to capture such dynamics and their inter-relations with the firm's entrepreneurial orientation.

2.3.1. Interaction Effect between Innovativeness and Proactiveness on Firm Growth

Existing literature tends to regard innovativeness and proactiveness as two closely related entrepreneurial dimensions. In a reconceptualization of EO, Anderson et al. (2015) combine proactiveness and innovativeness into a singular dimension as different from the risk-taking dimension. Their study states that "while innovation is a necessary condition for entrepreneurship, it is insufficient, nor is it meaningfully independent from proactiveness" (Anderson et al., 2015, p. 1583). This clearly signposts a closely related relation between innovativeness and proactiveness as dimensions of the entrepreneurial process. But what this closeness is exactly about needs more clarification. Are they similar? Are they different? Could they be both similar and different? Suppose they are both similar and different, how would the similarity interact with the difference? That is, is there any new synergy created by the similarity and the difference?

As an opportunity will not be an opportunity forever, it is crucial for firms to timely recognize and transform the opportunity into value generating innovations before the opportunity window closes. Proactiveness in this sense becomes a necessary condition to guarantee timely market entry and capture the value from the innovation. Meanwhile, the constant environmental scanning induced by proactiveness will increase the firm's ability to identify new information and new technological development trends, thus enhancing the firm's ability to come up with new ideas for innovation. Firms that are unable to track and perceive environmental changes are more likely to be caught up with problems than focusing on opportunities.

Lastly, being proactive to market not only could reap the benefits of being a first mover but could also shorten the time delay that innovative projects get paid off. Likewise, for a highly proactive firm to achieve high growth, it has to behave innovatively, at least to some extent. Because a firm could be very diligent in monitoring the environmental change but may be unable to come up with new ideas to take advantage of the perceived changes, or is unwilling to experiment with or implement the new ideas. Environmental scanning in this situation will be less likely to lead to positive growth outcome.

The above considerations seem to imply a complementary effect between innovativeness and proactiveness in identifying and exploiting new entrepreneurial opportunities. However, the interaction of proactiveness and innovativeness may also produce some damaging effect. Being able to generate a lot of innovative ideas and at the same time proactively capturing them will cause mounting resource pressure and increase the vulnerability of the firm.

2.3.2. Interaction Effect between Innovativeness and Risk-taking on Firm growth

Lomberg et al. (2016) find that the variance in risk-taking could cause negative firm performance if the variance is not aligned with the variance in innovativeness or proactiveness. Indeed, heavily leveraging firm resources without shipping something new to the market will reduce the likelihood of firm survival. Nevertheless, we cannot conclude from this that high risk-taking, when aligned with high innovativeness or proactiveness, will definitely lead to high long-term growth.

Being highly enthusiastic in experimenting with new potential innovations could cause high resource pressure for the firm. Firms face the difficult choice about whether they should be more risk-taking in this situation or instead should be more conservative. Because on one hand, the risky investment will worsen the resource pressure of the firm. Rosenbusch, Rauch and Bausch (2013) maintain that firms should not take too much risk and simultaneously do too much experimentation when in the situation of resource constraints. On the other hand, under difficult times the potential high return from risky investments provides as a potential means to fund the innovation projects. Sometimes taking risk is the only way to survive (Kahneman and Tversky, 1979).

In short, the above contradictory theoretical and empirical evidence leaves the interaction effect between innovativeness and risk-taking on firm growth unresolved.

2.3.3. Interaction Effect between Proactiveness and Risk-taking on Firm Growth

As proactively pursuing new opportunities will also cause mounting resource pressure of the firm, firms will probably also face the dilemma of whether to take more risk or to be more conservative when adopting a highly proactive posture.

Glaser, Stam and Takeuchi (2016) find that employee risk propensity negatively moderates the positive relationship between employee proactive behaviour and job performance. This study posits that taking initiative is an endeavour that usually involves risks and employees with high risk-taking propensity tend to perceive new initiatives more optimistically, thus underestimating the actual risks inherent as well as spending less effort to investigate the risks associated with the opportunity. This, therefore, results in less satisfactory job performance.

2.3.4. Interaction Effect among Innovativeness, Proactivensss, Risk-taking on Firm Growth

Scarcely any literature exists as to how innovativeness, proactiveness, and risk-taking interact to influence firm growth. This study aims to explore how the similarities, differences, and synergies between innovativeness and proactiveness will be altered under different conditions of risk-taking. For instance, the above discussion leads us to think that proactiveness may be a necessary condition for innovativeness to play a positive role on firm growth, while high risk-taking is counterproductive to the positive effect of innovativeness on firm growth. The question then arises is, will the detrimental moderating effect of high risk-taking on the innovativeness and firm growth relation be cancelled out by the beneficial moderation effect of high proactiveness on the innovativeness and firm growth relation?

2.4. Process Approach to Entrepreneurship

To study a phenomenon of interest, researchers need to make observations of it, then transforming the observations into data, and finally analysing the data. There are systematic differences in the ways in which researchers complete these procedures. Two commonly used approaches are the variance approach and the process approach.

2.4.1. Variance Approach and Process Approach

Mohr (1982) distinguishes two approaches to explain organizational behaviour: the variance approach and the process approach. The variance approach, which is prevalent in management studies, operationalizes observations into different kinds of variables and tries to explain the variance in the dependent variable through some independent variables. The process approach, in contrast, stands on a worldview that seeks to understand the world through conceptualizing processes rather than objects (Moroz and Hindle, 2012). A process approach explains how things develop and change over time. Change, rather than objects, is the cornerstone of reality in the process philosophy. In the process view, change is not something that happens to the entity, but it is the way that the reality exists (Langley et al., 2013). The focus of the process approach involves understanding how things change and develop over time. Variance approach allows us to investigate "what" questions, while process approach allows us to investigate "how" questions. The two approaches have different assumptions.

Variables lie in the heart of the variance approach. The phenomenon under investigation is always 'variabilizable' (Van de Ven and Engleman, 2004). Researchers tend to identify some key entities involved in the phenomenon and to ascertain their key attributes. These attributes will then be carefully defined as different variables. Each independent variable is considered to explain a certain portion of the variance in the outcome variable and the order of the independent variables is inconsequential. The unexplained variance in the outcome variable is assumed to come from random errors. The explanation of the phenomenon involves only a limited number of predefined variables and the explanation is usually in the form of 'the more X, the more/the less Y'.

The backbone of variance explanation lies in the causal mechanism that explains why changes in a construct will lead to a particular outcome (Wiklund and Shepherd, 2011). The causal mechanism, which usually is expressed in process terms, however, cannot be tested. Statistical models in empirical studies based on variance explanation are used to test the hypothesis, not the causal mechanism. Hypothesises are only conclusive statements about "what is expected to occur, not why it is expected to occur" (Sutton and Staw, 1995). As one hypothesis could have multiple completely different causal mechanisms underlying, passing a statistical test does not provide us evidence that the causal mechanism presented is the correct explanation. Besides that, in the variance approach, the role of time is to a large extent neglected. There is no time delay for an effect to take place—the effects of the independent variables are assumed to operate on the dependent variable immediately and continuously over time.

Another key issue in the application of variance approach is the difficulty in obtaining and analysing data at multiple time points. The cross-sectional design cannot ascertain the direction of causality and even if the data is collected at two different time points, the interesting twists and turns happened in between are left. Variance researchers, therefore, have been keeping calling for longitudinal research design. This problem precludes the variance approach from explaining phenomenon characterized by dynamic changes.

Process approach engages with understanding how things evolve over time, i.e. how the sequence of events lead to a certain outcome, and why they evolve in this way (Van de Ven and Huber, 1990). In this regard, events, rather than variables, are critical elements of an explanation. The unit of explanation is the process as a whole, which implicitly includes the role of time and that everything happened in the process is an integral part of the analysis. The temporal order of the events is also crucial to the explanation. Entities are also involved in process explanation, but only through the activities and actions that they perform. Attributes of entities do not play a role in the explanation unless they cause the occurrence of some events that are involved in the process. In the variance explanation, the entities and their nature remain constant, while in process explanation the number and nature of entities involved may change over time as the process unfolds. The process approach is most appropriate for investigating the temporally evolving phenomenon (Langley et al., 2013).

In terms of the logic of causal relationship and the nature of causes, variance explanation is based on necessary and sufficient causality—each independent variable is both necessary and sufficient to explain a portion of the variance in the dependent variable. In contrast, process explanation is solely based on necessary causality. Each event of the process is necessary but insufficient to the generation of the eventual outcome. This is because the entrepreneurial process is usually non-repeatable, due to the unpredictability and uncertainties involved.

To answer why related questions, Aristotle penetrates four causes behind all changes in the world (McKelvey, 2004; Dimov, 2011). These four causes are the material cause, formal cause, efficient cause, and final cause. The material cause refers to out of what material the thing is made. The formal cause relates to why something has that specific form. The efficient cause refers to what conducts the change. It is the only cause of the four that exists temporarily and that modern science focuses almost exclusively. The final cause describes the purpose or the goal for which the thing is done. Of the four causes, Aristotle considers the formal cause as the most important cause of things and that the efficient and final causes flow from the formal cause. Variance explanation is only based on the efficient cause while process explanation draws on the final cause.

There is also a significant difference between the role of randomness in the variance approach and that in the process approach. The variance approach is deterministic, which means "luck", no matter good luck or bad luck, does not play a role. In the process approach, however, a random event may profoundly change the whole course of the process as well as the eventual outcome. The problem is that randomness poses challenges for the theorizing and application of process theory, as it is not always easy to distinguish whether the random event is truly exogenous or is triggered by the attributes or activities of the entity.

2.4.2. Studying Entrepreneurship as a Process

Scholarly examination of the field of entrepreneurship should not only include the content of entrepreneurship, i.e. "what do entrepreneurs or entrepreneurial firms do", but also the process of entrepreneurship, i.e. "how do they do it?" (Lumpkin and Dess, 1996; Moroz and Hindle, 2012). Although the field of entrepreneurship is dominated by research employing linear regression model and using data collected at one or two time points, it is universally acknowledged that entrepreneurship by nature is a process (McMullen and Dimov, 2013). Why entrepreneurship is a process and how entrepreneurship could be a process? Entrepreneurship could be and should be conceptualized as a process in the sense that it is about getting from a starting point to achieve an ending of new goods and services coming into existence (Venkataraman, 1997). The outcome or the goal of entrepreneurship cannot be completed in one go, but is a complex task that requires continuous efforts with the actions and events emerging in sequential order (Dimov, 2018).

The entrepreneurial process is characterized by nonlinear and discontinuous events that require a departure from the method designed for smooth, continuous, and linear processes that are usually repeatable (Churchill and Bygrave, 1989). Under the variance-oriented conceptualization of entrepreneurship, the role of time is neglected, so are the dynamics of the entrepreneurial process. Studying entrepreneurship as a process will not only reveal the twists and turns in the entrepreneurial journey but will also help distinguish entrepreneurship from other fields of study, such as strategic management and creativity research (McMullen and Dimov, 2013).

There are some studies adopting the process approach in the entrepreneurship domain. However, not all research that claims to have adopted a process approach is the same. Aldrich (2001) distinguishes outcome-driven and event-driven research in the study of organizations. Outcome-driven research builds the explanation from known outcome to preceding events that are causally significant. This inevitably leads to the researchers' selection of the outcome variable and events that make up the explanation. This kind of research is also susceptible to the sample selection bias as not all organizations that have gone through the events will survive until the end. Event-driven research, in contrast, is built forward, from the observed events to the outcome. Researchers record the occurrence of the different events as time goes by and construct a narrative describing how things develop over time.

In addition, there also exist different interpretations of the term "process" (Van de Ven and Engleman, 2004). One interpretation is process as an entity characterized by different attributes. These different attributes are represented by independent variables, which are then examined statistically with regard to how they affect the variance in the dependent variable. Take the study of decision-making process as an example, attributes of this process such as decision-making speed are taken as independent variables to explain the outcome of the decision making, which is represented as a dependent variable. Although the "process" implies the existence of activities and events in between the beginning and the end of the process, these activities are not captured. This interpretation actually renders the process into a variance theory of change. The problem of this approach is articulate in Poole et al. (2000, p. 29):

> "While the variance approach offers good explanations of continuous change driven by deterministic causation, this is a very limited way to conceptualize change and development. It overlooks many critical and interesting aspects of change processes. However, because most organizational scholars have been taught a version of social science that depends on variance methods, and because methods for narrative research are not well developed, researchers tend to conceptualize process

> problems in variance terms. One can see the 'law of the hammer' in operation here: Give a child a hammer, and everything seems made to be hit; give a social scientist variables and the general linear model and everything seems made to be factored, regressed, and fit".

The second interpretation is process as a sequence of events that unfold over time. Under this interpretation, process theory is in the form of a historical narrative depicting the sequence of events that happens. This is the kind of research that has been called for by many scholars in order to develop more understanding of the entrepreneurial process.

Based on the two different empirical interpretations of process, McMullen and Dimov (2013) add a second distinction, i.e. the entrepreneurial outcome as distal or proximate, to review the existing process research in the domain of entrepreneurship. In their view, the most interesting studies are those interpreting process as a sequence of events and with a focus on distal outcomes. The example used is Venkataraman et al. (1990), which come up with a process model of how small firms fail based on a longitudinal study of ten new firms in the educational software sector. However, of the 15 empirical papers reviewed in the study, only one belongs to this category.

2.4.3. Process Explanation: From Sequence of Events to the Underlying Generative Mechanism

Process explanation usually comes in the form of a sequence of events causally and temporally connecting with each other to explain the outcome in the end (Hekkert et al., 2007). The efforts to identify the activities and sequence of events forming entrepreneurial process are not rare. However, the problem of this kind of entrepreneurial process story is that at a given time there could be numerous events and activities happening for a certain entity and for its surroundings. These events are not all "observable" to all people. Given a certain causing event, there could be multiple plausible resulting events. Likewise, given a certain resulting event, there could be found multiple plausible events causing it. The result is that, if we take each dot in Figure 2.1 as an event, there could be numerous possible lines of logics explaining how things evolve from the beginning to the end. Apparently, they could not be all true for a certain firm at a certain time.

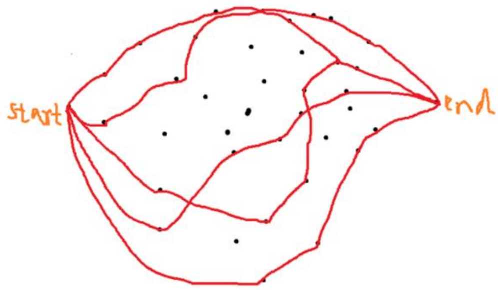


Figure 2.1 Entrepreneurial process

Furthermore, the logics used in event-based process explanation may be well regarded as an extension of the cause-effect explanation in the variance approach—every event has a causing event and every causing event has another causing event. Instead of one cause-effect relation, the event-based process explanation traces down a chain of cause-effect relations that could extend indefinitely—until exhausting the researcher's knowledge scope or interest.

Secondly, the non-negligible role of contingencies on the entrepreneurial process implies that had the process unfolded again, it might unfold differently. The process explanation based on the sequence of events has limited explanatory power in the sense that it is likely to degenerates into a constructed explanation of a particular sequence of events for the sake of an already known ending. Penrose (1959, p. 26) comments that:

> "Accordingly, a theory purporting to explain the process of growth of firms can be useful on two levels. It can be useful even if it only presents a logical model yielding conclusions which seem to correspond to actual events that can be 'observed' in the growth of actual firms. But it will be even better if it helps us to understand the actions behind these events."

Apparently, to develop a process theory involves more than a description of the sequence of events. Researchers have to be able to penetrate through the series of events into the underlying mechanism that drives the progression of the events (Van de Ven and Poole, 1995; Langley, 1999). That is, what are the driving activities and structures that make certain events happen to a certain firm in a certain order?

Van de Ven and Poole (1995) explain four different generative mechanisms that drive organizational change. This task of uncovering the underlying generative mechanism while developing theoretical explanations that reach beyond the surface observations and that could gain application in wider situations, however, is a considerable challenge, given the ambiguous, complex, and massive information in process data (Langley et al., 2013). Most representations of organizational processes tend to draw on the life stage model, which explains change in linear and predictable ways. Organizational processes, however, involve feedback loops and nonlinear relationships that are beyond the rigor of the linear stage model.

2.4.4. EO and the Generative Mechanism Behind Entrepreneurial Process

Despite discussions on the dimensionality of the EO construct, that EO is a concept initially intended to conceptualize entrepreneurial processes within firms has been explicit in both the unidimensional and multidimensional views of EO (Miller, 1983; Covin and Slevin, 1991; Lumpkin and Dess, 1996). The way in which this concept has been used so far, however, diverges from its original intention (Randerson, 2016). EO and its dimensions have been used as variables, which makes the entrepreneurial process, the underlying mechanism, and the time element obscured (McMullen and Dimov, 2013).

The challenge of constructing a process model of entrepreneurship lies in identifying the activities generic to all entrepreneurial process while at the same time explaining why a firm's entrepreneurial journey unfolds in this particular way (Dimov, 2018). As mentioned earlier, Van de Ven and Poole (1995) have identified four motors driving different sequences of change events, including the life-cycle motor, teleological motor, dialectical motor, and evolutionary motor. In the entrepreneurship studies, the opportunity-based framework by Shane and Venkataraman (2000) represents an influential framework that identifies the generic processes of entrepreneurship through the existence of entrepreneurial opportunities, and the identification and exploitation of entrepreneurial opportunities (Moroz and Hindle, 2012). Van de Ven and Poole (1995) distinguish "motors" or "generative mechanisms" as deterministic or constructive, according to whether the theory explains things' development in a predetermined order or not. The motor behind the entrepreneurial process, which is characterized by risk and uncertainty, should be undoubtedly marked as a constructive motor, as the sequence of events emerged during the entrepreneurial process and the end results cannot be pre-determined.

Then the next intuitive move to develop the opportunity-based motor is to investigate how these generic processes produce heterogeneous entrepreneurial journey. The key here is to recognize that the opportunity-based framework identifies some marking events and processes that typically happen in every entrepreneurial journey. But it does not go further to understand how each of these subprocesses is executed. For the same process, the agents vary in their way of engaging. Firms vary in their "methods, practices, and decision-making styles to act entrepreneurially."(Lumpkin and Dess, 1996, p. 136). In this regard, the concept of EO could be the way forward to "characterize and distinguish key entrepreneurial processes" (Lumpkin and Dess, 1996). Simply putting, the opportunity-based framework explains the generic entrepreneurial processes, while the concept of entrepreneurial orientation stands to depict how these generic processes are executed differently. The entrepreneurial outcomes due to different EO conditions contribute to the unique aspect of the entrepreneurial process. That is, it enables us to understand why one entrepreneurial journey unfolds in this particular way.

To further clarify the concept of the generative mechanism and the role of EO in the generative mechanism behind the entrepreneurial process, it might be helpful to draw an analogy from biology about how DNA works to regulate life. In almost all human cells, DNA leads to the building of protein, which essentially gives rise to our different characteristics, through two generic processes, i.e. transcription and translation. During the transcription process, information stored in DNA is copied to messenger RNA. Messenger RNA then carries the information to the "construction site" of protein. During the translation process, ribosomes and transfer RNA work together to select and organize the amino acids in a specific sequence as written in the genetic code in messenger RNA to build protein. The fundamental process flow from DNA to RNA to proteins is regarded as the "central dogma" in molecular biology and is identical across almost all cells. However, the sequence of nucleotides within a gene dictates what type of amino acids and how the amino acids are put together to form which kind of proteins, which then form our cells, then tissues, and organs.

The opportunity identification and exploitation processes may be comparable to the processes of transcription and translation in biology, while the role of EO may be comparable to that of the genetic codes that dictate the exact executions of these processes. The opportunity based framework by Shane and Venkataraman (2000) and

EO work together to shed light on the the homogenous and heterogeneous nature of the entrepreneurial process.

2.4.5. Evolutionary Approach and Complexity Science

Collecting longitudinal data, whether in the form of archival, historical or field observations, is difficult and time-consuming. As the call for longitudinal research on the entrepreneurial process goes constantly unanswered and most process research render into attributes study by nature, a call for the application of computer simulation method is made to gain theoretical insights into interesting phenomenon (McKelvey, 2004; McMullen and Dimov, 2013).

McKelvey (2004) compares thin and thick explanations of entrepreneurial behaviour. Thin explanations, as prevalent in the empirical studies of entrepreneurship, typically use econometric analysis of time-series data and are disadvantaged in their inability to accommodate many causal effects. Thick explanations, which use narrative analysis, in contrast, are disadvantaged in their generalizability. McKelvey thus argues that science is poorly served by either of the approaches and instead proposes the “model-centered” approach, that is, theory developed through formal models, to combine thin- and thick- explanations. McKelvey (2004) explicitly critiques the use of the evolutionary approach (Aldrich, 2001) to explain entrepreneurial behaviour. He points out that evolutionary theory describes the equilibrium process while the entrepreneurial process is about new order creation.

The essential difference between the process approach advocated by Aldrich (2001), Langley (1999), and Van de Ven and Engleman (2004) and the formal modelling approach advocated in the complexity science view is essentially a question of when constructing the process theory is it from the surface sequence of events to the underlying generative mechanism, or from the underlying generative mechanism to the events. The process theory derived from a narrative story is essentially and inevitably only about the past, with no mechanism (or very limited mechanism) to test the theory’s application into the future.

Overall, this study adopts a simulation based process approach to understand how entrepreneurial process unfold within firms, how EO dictates the entrepreneurial process, and how entrepreneurial process interacts with other organizational processes to generate firm growth. Insights from the simulation based process approach are expected to shed light on the long term firm growth patterns generated by different EO conditions and to reveal how to effectively manage the entrepreneurial process—a question posed by the EO-as-experimentation view, to achieve long term high growth (Wiklund and Shepherd, 2011). These research questions are difficult to address through linear regression models. Computer simulation is an effective method for theory development when the focal phenomenon involves multiple processes, time delays and feedback loops (Davis, Eisenhardt and Bingham, 2007).

2.5. Firm Growth Studies

Studies on firm growth could be classified into the following categories:

2.5.1. Variance Studies on Firm Characteristics and Firm Growth Rate

In management studies researchers tend to explain differences in firms' growth rates over time using a variety of predictors, such as entrepreneur's personal characteristics (Gielnik, Zacher and Frese, 2012), attributes of firm resources (Mishina, Pollock and Porac, 2004), firms' strategic orientation (Moreno and Casillas, 2008; Anderson and Eshima, 2013), and so on. This literature stream adopts statistical analysis techniques, generally linear regression analysis, to explain the variations in firm growth rates (Davidsson, 1991; Gielnik, Zacher and Frese, 2012; Anderson and Eshima, 2013). Data on the dependent variable is usually collected a few years after that of the independent variables. As the dependent variable is measured only at a time point, this kind of studies cannot reveal what growth is like in between the two time points. The interesting surges and reversals in the growth process are beyond the explanation of the variance research design.

At the same time, diverse measures of firm growth have been used across studies, such as employment growth, sales growth, assets growth, and so on. Using growth data of Swedish firms over their first 6 years of existence, Shepherd and Wiklund (2009) find low shared variance among the different growth measures. Studies not only use different time spans in measuring growth but also differ in the formulas used to calculate firm growth rate, i.e. absolute growth vs. percentage growth. Furthermore, the majority of empirical studies on firm growth are subject to survival bias. Whether firms could achieve growth and survival goals simultaneously or must trade off one against the other remains a myth.

Due to the inconsistencies across studies, the negligence of survival bias, and the inability to distinguish internal growth from acquisition and merger, knowledge integration across these studies has been difficult.

2.5.2. Life Stage Theory of Firm Growth

In life stage theory, firm growth is viewed as an orderly periodic progression of some qualitatively different stages. These stages are characterized by different organizational characteristics (Hanks et al., 1993) and organizational problems (Kazanjian, 1988) that are created out of growth. Progression from each stage to the next is said to be accompanied by some crises or revolution that must be resolved before growth can continue (Greiner, 1972; Scott and Bruce, 1987).

These life stage models are typically induced from case studies, and studies on empirical validation of these models generally adopt ANOVA or cluster analysis to classify firms into several different categories. However, as the research design is cross-sectional by nature, the sequence of these stages and that firms proceed the stages in sequence cannot be demonstrated (Kazanjian, 1988; Hanks et al., 1993). There also lacks consistency across studies in the number of the life stages, the duration of each stage, and the organizational dimensions used to categorize the stages. At the same time, the variables used to classify stages tend to be quite general that sometimes it is not easy for firms to identify the stages they are located. Furthermore, in reality, firms could make administrative and technological adaptations at the same time with each expansion made. Therefore, there does not necessarily exist a clear boundary between stages.

Lastly, while the life stage theory adopts the biological metaphor which is very intuitive for managers to understand the phenomenon of firm growth, its underlying assumptions of firm growth as linear, deterministic and predictable have suffered wide critique of being unrealistic (Phelps, Adams and Bessant, 2007).

2.5.3. Firm Growth as a Random Process

Recognizing the limitations of the above empirical studies on firm growth, some studies try to understand the dynamics of firm growth over time, with a focus on investigating the relationship between firm size and firm growth rate. In studies of the dynamics of firm growth, the proposition that firm growth rate over time as a random process has attracted a significant amount of attention.

Empirical studies on firm growth from the economics literature have indicated that despite some factors such as firm size and firm age that have been shown to have "at least transitory effects" on firm growth, firm growth rate to a large extent is a random process (Geroski, 2005). After an examination of existing empirical models of firm growth, Geroski (2005) concludes that firm growth rates over time as random is just about what to predict from these models. However, a problem goes unnoticed is, what we can conclude from these empirical models is merely that firm growth rate is linearly independent of firm size. Because empirical testing of the proposition that firm growth is a random process focuses on the following model:

$$\text{Growth rate}_i = \grave{a} + ß * \text{firm size}_{i-1} + \check{e}$$

In this equation firm growth rate and firm size are linearly linked. The conclusion that firm growth rate as independent of firm size and as a random process will be arrived if ß=0. But from the view of complexity science, firm size and firm growth rate could be linked indirectly through a complex cycle of interactions (Richmond, 1993), which cannot be found out by statistical testing of linear models.

In explaining the process of firm growth, there is also the influential Gibrat's law of proportionate effect, which holds that firm growth rate is unrelated to firm size and is a random process. According to Gibrat's law, firms in a given industry have the same probability of experiencing a given proportionate change in size during a specific period. Firm's growth rate is generally represented by an i.i.d. normally distributed growth shocks. This stochastic process leads to the lognormal firm size distribution, which resonates with the size distribution of French manufacturing firms. The Gibrat's law has attracted a good amount of attention due to its novel proposition that firm growth rate does not seem to vary with firm size and due to its ability to produce the observed firm size distributions.

However, there are also empirical studies finding violations to Gilbrat's law. Using Chi-square analysis to test Gibrat's law, Mansfield (1962) finds that Gibrat's law has failed to hold empirically, as smaller firms show higher failure rates and those survived have higher and more variable growth rates than larger firms. He concludes that Gibrat's law as rather unreliable to rest theories of the size distributions of firms, and calls for a more sophisticated model of the firm growth process. His study also reveals the role of innovation on firm's growth rate−firms that implement successful innovations in a period could grow twice that of other comparable firms. Evans (1987a, b) find that firm growth decreases with firm size. But unlike other studies that assume a linear relationship between firm growth rate and firm size, Evans (1987a, b) find that this relationship is highly nonlinear as it varies over the size distributions of firms and that the rate at which firm growth decreases as firm size increases is diminishing.

Despite issues related to empirical validities of the Gilbrat's law, the issue this study intends to point out is that sometimes it is not easy to distinguish random process from chaotic process. In investigating the developmental processes of biomedical innovations, Cheng and Van de Ven (1996) find that the innovation process which was commonly interpreted as a random sequence of blind events actually is a chaotic process, which is generated by a nonlinear dynamical system that is neither deterministic nor stochastic.

2.5.4. Firm Growth as Auto Correlated Process

Another branch of firm growth study is on the autocorrelation of firm growth, which considers firm growth rate not related to firm size but related to firm growth rate at the previous time. Ijiri and Simon (1964, 1967) show that stochastic processes based on Gibrat's law but at the same time admitting serial correlation whereby the growth rates of individual firms are related to their growth rates in preceding periods could also lead to empirically observed firm size distributions. Bottazzi and Secchi (2003, 2006) model firm growth as a positive feedback process whereby the more opportunities captured by a firm, the more likely the firm is able to capture a new opportunity. This mechanism reproduces the tent-shaped distribution of firm growth rates that has emerged as a robust and universal characteristic of the time evolution of corporate.

This literature indicates that firm growth is a feedback process in which growth in the last period will influence growth in the next period. Opportunities and growth are related in the simplest way in these studies and luck is the principal factor distinguishing firms that could take more opportunities and grow more from firms that fail to capture opportunities. It might be worthwhile to explore whether there exists some deterministic mechanism behind firm growth and how this deterministic mechanism when coupled with randomness produces certain growth outcomes—

Growth as a random process does not advance our understanding of the phenomenon of firm growth, as for every matter in the world there is a random element. The key is to succeed out of randomness, to succeed out of uncontrollable things.

Repenning (2000, p. 179) posits that ‘while the existing literature typically asserts the existence of one or more reinforcing loops responsible for the exponential growth of firms, it contains no discussion of the conditions required for the loop to dominate the behaviour of the system in which it is embedded.’. An important characteristic of the self-reinforcing loops is that they could not only work as virtuous circles driving things to grow but also work as vicious circles driving things towards decline. Understanding the conditions under which the reinforcing loop works as a positive growth loop and what triggers its transition to a vicious circle, therefore, are of importance. Relatively little attention has been paid to the limits to growth, i.e. the negative feedback loops that would constrain the dominance of the positive reinforcing loop.

Overall, the above literature suggests that perhaps new insights could be gained if we move away from employing linear models in understanding firm growth, and if we shift our attention to the complex mechanism behind firm growth process. Penrose theory of firm growth (Penrose, 1959) in this respect provides as a good foundation as it explains how firms grow, i.e. the generative mechanism behind the growth process.

2.5.5. What is Firm Growth?

An interesting question that emerges after a review of the different streams of firm growth literature is that not many studies contain a formal definition of firm growth. This negligence could be understandable given that growth accompanies almost every organism that it is easy for us to take what growth is for granted. However, it is important to note that firms are not “organisms” −they are not born with the DNA programs that spontaneously dictate growth. Growth in firms may be interpreted differently from growth in organisms.

Of the rare studies which provide definition of firm growth, Mishina, Pollock and Porac (2004, p. 1108) define firm growth as business expansion in two dimensions, that is, “the fundamental activities of growing by extending the market for an existing set of products (market expansion) and growing by developing new products for existing markets (product expansion).” This is in contrast to the economy of scale view, which assumes the growth of firm as the mere increase in the amount of production or sale of certain products.

Despite the absence of a formal definition of firm growth in most studies, firm growth has been commonly implied to be the change in firm size or the amount of expansion the firm achieves during a period of time (Geroski, 2005). However, as to what firm size or firm expansion refer to, the literature again, seems to assume that it is all clear and simply use indicators such as firm sales, the number of employee, total asset as representation (Mueller et al., 2012; Anderson and Eshima, 2013; Andrevski, Brass and Ferrier, 2013; Coad et al., 2015; Coad, Segarra and Teruel, 2016).

Sales growth has been deemed the most post popular indicator of firm growth (Shepherd and Wiklund, 2009), as sales growth brings revenues that could be reinvested for expanding the firms' resource base or developing capability (Gilbert, McDougall and Audretsch, 2006). However, this indicator has been criticised for being volatile and susceptible to trivial changes in firm growth (Coad et al., 2015). The second most used indicator of firm growth is the number of employees. In the early days of industrial production, any increase in the output of a firm will inevitably lead to the expansion of production equipment and a rising number of labours involved. However, in the era of auto-production and information technology, employee number has gradually become a questionable measure to represent the size of a firm. Nevertheless, employee number might be a good indicator to assess firms' contribution to job creation in the economy. Arguably, the other measures of firm growth could all reflect only certain aspect of "firm size". For example, the indicator of total firm assets has been criticized for being highly sensitive to the capital intensity of the industry (Lockett et al., 2011).

Studies have further demonstrated that these different measures of firm growth do not always positively correlate with each other (Shepherd and Wiklund, 2009). Commitment into R&D and innovation could lead to increased productivity and sales, but will result in declining demand for labour (Coad, Segarra and Teruel, 2016). Investment into advertising could lead to increasing sales growth but it will cause declining firm profitability. Firms labelled as high-growth firms using one indicator may not be high growth firms if using another indicator (Delmar, Davidsson and Gartner, 2003). While scholars in the management discipline struggle to find a satisfactory indicator to capture firm growth, the economics literature simply uses a symbol, usually “s”, to denote the “size” of the firm, without being precise of what firm size means (Geroski, 2005).

As scholars in the management disciplines struggle to find a satisfactory indicator to capture firm growth, it may go unnoticed that the difficulty in coming up with a satisfactory measure of firm size or firm growth may not lie so much in the disadvantages of the indictors themselves, but in the ambiguity and lack of understanding of the nature of firm and that of firm growth. As mentioned earlier, many studies implicitly take firm growth as the change in firm size. However, the question of what firm size refers to may effectively regress back to a question of what firm growth is, because firm size is the outcome of a process of development. This study concurs with the view by Penrose (1959) that firm size is the result of a process of development, without eliciting which, it might be imprudent to provide any arbitrary definition of firm size.

From the Penrose’s conceptualization of firm as a collection of resources, the resource-based theory has approached the analysis of firms from the resource side (Barney, 1986; Barney, 1991). Penrose (1959) contends that firm resources shape the productive services the firm is capable of rendering and Wernerfelt (1984) views products and resources as “two sides of the same coin”. Danneels (2002) finds that product innovation and firm resource interact with each other and co-evolve over time in a path-dependent manner. From the resource-based view, (organic) firm growth process involves the recombination, creation, and accumulation of firm resources in a complex, path dependent process (Dierickx and Cool, 1989; Eisenhardt and Martin, 2000; Pettus, 2001; Danneels, 2002; Rugman and Verbeke, 2002; Foss et al., 2008; Lockett et al., 2011).

This study adopts the resource-based approach to understand firm growth (Nason and Wiklund, 2015), and considers the firm expansion process as a process of expansion in the firm’s resource base. As Penrose says, “when we regard the function of the private business firm from this point of view, the size of the firm is best gauged by some measure of the productive resources it employs.” (Penrose, 1959, p. 24). This conceptualization has been adopted in existing studies. For example, Delmar, Davidsson and Gartner (2003, p. 194) are of the view “If firms are viewed as bundles of resources, a growth analysis ought to focus on the accumulation of resources”.

2.6. Penrose Theory of Firm Growth Process

2.6.1. Firm and Firm Growth in the Penrose Theory

The Penrose theory was developed around the 1950s by drawing on the growth experience of an industrialized firm, the Hercules Powder company (Penrose, 1960). This theory drew upon, as Penrose explicitly expressed it, the theoretical and applied economics, but at the same time stood against some key assumptions of the economic view of the firm. Therefore, to gain a better understanding of the Penrose theory, it might be helpful to include the analysis of traditional economic theories of firms as a comparison.

The first important point to distinguish between the Penrose theory and the traditional neo-classical economic theory is the assumptions they hold on what “firm” means and accordingly what firm growth refers to. In traditional economic analysis, firm growth refers to the increase in the amount of output for certain products. The economic theory analyses the associated advantages and disadvantages of different firm sizes, with the advantage and disadvantage mainly referring to the cost of production. Firm growth in this sense only means the change in firm size, while there is a lack of the process of development. The change in firm size or in the scale of production is at the same time the process, the purpose, and the outcome of firm growth. This view of firm growth is closely related to the underlying view of the firm in the theory, where the firm is nothing more than a black box with rather simplified input and output.

The Penrose theory, however, regards firms as “innovating, multiproduct, and ‘flesh-and-blood’ organizations”. This conception effectively conveys that the characteristics of firms could not be reduced to cost and demand curves. A large part of the economic activity is carried out through firms. In the Penrose theory, firm functions as an economic entity to provide goods and services to the economy by making use of the production resources it possesses. Two elements are identified by Penrose as central to this definition of the firm, that is, the administrative framework and the resources of the firm. The administrative framework lays down policies that make the activities within the firm interrelated and coordinated, and sets a boundary between the economic activities that happen within the firm and those happen in the market. Firm growth is of significance to the economy in the sense that the larger the size of the firm, the less the resource allocation into different uses is subject to market forces, but more subject to conscious planning of an individual firm. However, the firm is more than an administrative framework. It is also a collection of resources, the uses of which are subject to administrative decisions. Firm growth, in the context of 1950s, is regarded as “the continual extension of the range and nature of the activities of an organization” in Penrose theory (Penrose, 1959, p. 6). There is essential difference between firm size and firm growth, because “Growth is a process; size is a state”. The Penrose theory maintains that the increase in firm size is only one of the by-products or the unavoidable consequences of a process of development. And thus, the Penrose theory is primarily concerned with understanding and explaining the process of development, rather than firm size. Besides the changes in firm size, firm growth also results in changes in the characteristics of the firms.

Secondly, the Penrose theory questions the proposition by economic theory that there exists an optimal firm size where all firms should cease to grow. The equilibrium analysis requires a limit to firm expansion and the optimal firm size in economic analysis comes into existence by imposing the assumption that the cost of producing additional quantities of products will rise after a point and that the demand for the product is limited, i.e. does not go up as the cost of production rises. Profit in the optimal size is maximized as the economy of scale is traded off against the increasing costs of coordinating activities within large organizations (Coad, 2007). Therefore, it is not wise for firms to continue growing unlimitedly. This analysis also implies that different firm sizes mean different advantages and disadvantages in the profiting ability of the firm. This most profitable size is the reason and motivation behind firms’ movement from one size to another. This view, however, has been criticized for its lack of empirical support, as the economy is not composed of firms with the same size by any means.

Specifically, the Penrose theory challenges the existence of this optimal firm size by re-examining the existence of the limitation in management and the limitation in market demand. In the first aspect, Penrose argues that the managerial diseconomy will only cause the rise in long-run production cost when the management is treated as fixed. The finite human capacity, however, does not apply when different personnel within the firm could fulfill the managerial tasks. The firm could always adjust its administrative structure to the new requirement as it grows and changes. In this condition, the firm will not grow to a point that it is too big to be efficiently managed. For the latter, the limitation in the market is essentially derived from the assumption in economic analysis that firms are constrained to produce only certain products and that the market demand for the products is limited. Penrose recognizes that firms are free to alter the range of products or services that they produce, the processes of which give rise to new market demand. In this sense, market demand is not fixed, but could be "found" or "created", and firm growth needs not to be subject to the limitations in the original market. Dropping this assumption offers good scope and a good angle for the Penrose theory to elicit the underlying processes of firm growth. This limitation in market demand thus transforms to a question of why some firms are able to produce new products while others are not.

2.6.2. Firm Resource and the Productive Opportunity Set

To shed light on why some firms could produce different products while others do not, Penrose turns attention to the internal of the firm, rather than looking at the external environment. Firstly, for firms to expand, except the motivation to expand for the sake of long-term growth, there needs to be the physical presence of the possibility of growth that acts as an internal inducement for firms to expand. According to Penrose, this inducement and the possibility of growth derive from the constant existence of a bundle of underutilized resources of the firm. As long as there are more profitable ways to make use of current resources, firms with even average entrepreneurial resources will be motivated to find new ways of using these resources more fully. It is the unused firm resources that provide as the incentive as well as the means for firms to pursue further growth and an economy of expansion in certain directions.

Secondly, while unused firm resources are the sources of firm growth, a theory of firm growth should also incorporate the explanation of why the same resource condition could end up into different products and different growth outcomes. In terms of this question, Penrose makes the distinction between firm resources and the productive services the resources could render. The productive services are a function of the way in which resources can be used. The same resources when used in different ways could produce a different set of services. Therefore, uniqueness could come into place even when the firms have exactly the same resource endowments. The relationship between resources and services is such that the productive services that the resources could render are not given ex-ante, but are dependent upon firms' subjective insights. Penrose applies a subjective perspective into the study of firm resources (Baker and Nelson, 2005; Foss et al., 2008). In the Penrose theory, the external environment is an image in the entrepreneurs' mind. The firms could conceive new productive uses of its existing underutilized resources. These new productive uses of the firm resources constitute the productive opportunity set of the firm, the concept of which makes the Penrose theory easily connectable with the more recent entrepreneurship literature.

> "The productive activities of such a firm are governed by what we shall call its 'productive opportunity', which comprises all of the productive possibilities that its 'entrepreneurs' see and can take advantage of. A theory of the growth of firms is essentially an examination of the changing productive opportunity of firms; in order to find a limit to growth, or a restriction on the rate of growth, the productive opportunity of a firm must be shown to be limited in any period" (Penrose, 1959, pp. 31-32).

While the firm may come up with many different uses of its existing resources, i.e. possessing a big productive opportunity set, the amount of expansion the firm could conduct at a given time is limited. Penrose believes this limitation in growth derives from the limited managerial resources available to the firm at a given time. Penrose argues that firm as an administrative and planning organization, its expansion projects need to be planned and carried out by the management team. The existing management capacities of the firm controlling these plans set a limit to the amount of expansion the firm could conduct in any given time. This managerial service cannot be acquired by simply recruiting new managers in the market place, because management works as a team or as a 'unit'. The management teamwork is more than a gather of its individuals. Teamwork requires knowledge and confidence in each other and it can be developed only when the collection of individual managers have experience of working together with each other. This experience gained from working with each other creates unique valuable services that managers outside of the firm cannot provide.

It not only takes time for the development of new managerial service, but the amount of new management capacities that could be developed, i.e. the amount of new managerial personnel that could be 'absorbed' is also contingent on the firm's previous managerial resources. Penrose maintains that the managerial service is the necessary input into firm expansion process. Hence, the managerial service poses as a fundamental and unavoidable limit to firm growth. Although the firm may have a large productive opportunity set, the existence of this managerial limit constrains firms' ability to take advantage of all opportunities in the firms' productive set and sets a limit to the amount of expansion the firm could conduct at a given time.

2.6.3. Firm Growth as a Dynamic Feedback Process

However, this managerial limit is not fixed, but dynamic and receding. Once the expansion is completed, the managerial services are released and could be applied into the next round of expansion. The process of expansion usually involves the recruitment of new managers and the further decentralization of authorities. New managers are thus cultivated during the process of expansion, which creates new managerial services available for firm expansion in the future. As the amount of expansion conducted at present will determine the number of new management staffs that could be cultivated in the next period, the amount of expansion a firm could conduct at a given time is not only limited by its current managerial capacity but also indirectly affected by its previous managerial capacity. This implies that firm growth at the current time is influenced by how much the firm grows in the previous time. This resonates with the reinforcing firm growth process in the firm growth literature—how much firm grows in the current period will bear influence on how much it grows in the next period.

The equilibrium condition may be possible and the static approach may be appropriate if the productive opportunity set of the firm remains unchanged over time. Under the hypothesised condition of constant managerial knowledge, one may argue that there will be a time when the productive opportunity set of the firm is depleted and the firm growth will cease. Penrose excludes this possibility by raising the point that the productive opportunity set is dynamically changing instead of fixed. The firm expansion process is not only a process that the management team gains more experience in working with each other, but the experience gained during firm expansion process also leads to the increase in knowledge as well as the improved capability to use knowledge. The outcome of this increase in knowledge is that the productive opportunity set of the firm will also change. The increased knowledge of the possibilities for actions and the ways in which action could be taken open up new productive opportunities that did not emerge at the time when the expansion was made.

This interplay between firm resources and the firm's improved capacity to conceptualize new productive uses out of the resources gives rise to a dynamically changing productive opportunity set of the firm as it grows.

Remembering that the incentive and possibility of growth in the Penrose theory come from the existence of a bundle of underutilized firm resources. The possibility of the equilibrium condition then also hinges on whether the firm will reach a position where the unused firm resources are used up in the process of growth, whereby firm has no further incentive or possibility to grow. In this respect, Penrose suggests that this possibility of equilibrium condition is precluded if we take certain characteristics of firm resources into consideration. Specifically, because of the indivisibility, specialized use, heterogeneity, and the constant creation of new productive services of resources during the expansion process, there are always a bunch of unused productive services available within the firm.

The continuing availability of underutilized firm resources, dynamically changing productive opportunity set, and the dynamic, as well as receding managerial limit, result in a growth process whereby firms could continuously grow, but the rate of growth at a given time is limited. Also due to all these aspects, the firm will never reach an equilibrium status in which it has no further internal incentive to expand, even when the environmental condition remains unchanged. These feedback processes result in a dynamically ever-changing productive opportunity set and forms a feedback growth mechanism which expansion in the last step will influence expansion in the next step. It is these dynamic feedback processes that give rise to the unique productive opportunity set of each firm and create the heterogeneity across firms. The Penrose theory explicitly refutes, and all aspects of its arguments form as a sharp contrast to the static theory of the firm.

2.6.4. The Economy of Firm Growth

Like the economic theory, the Penrose theory also tries to identify if there is any condition that will enable a firm to be in a better position to grow than the other firms. The Penrose theory posits that as a result of the dynamic processes of development, each firm possesses a unique collection of productive services that gives itself the advantage to expand in certain directions than the other firms. Penrose names this advantage of growth as the "economy of growth". Interestingly, while the economy of scale and economy of scope suggest that firms with a bigger scale of operation have an advantage over smaller firms in terms of growth, the economy of growth implies that any firm could be at an advantage to grow in certain directions than the other firms. This economy of resource utilization is unrelated to the size of the firm but is related to the process of growth of the firm. Understandingly, this economy of growth only exists during the process of growth. Once firm growth ceases, this economy of growth disappears.

2.6.5. The Role of Entrepreneurship in Penrose Theory

Entrepreneurship is an indispensable element in Penrose theory, as entrepreneurial services are crucial in the conceptualization and exploitation of new productive opportunities (Garnsey, Stam and Heffernan, 2006). As Penrose explicitly stresses the role of "entrepreneurial services" in her theory:

> "There surely can be little doubt that the rate and direction of the growth of a firm depend on the extent to which it is alert to act upon opportunities for profitable investment. It follows that the lack of enterprise in a firm will preclude or substantially retard its growth, although 'enterprise' is by no means a homogeneous quality……" (Penrose, 1959, p. 30).

Entrepreneurship in Penrose theory is treated as the psychological predisposition of an individual to speculative activities and as a kind of productive service with heterogeneity quality, which is distinguished from managerial services. Entrepreneurial services contribute to firms the introduction and acceptance of new ideas, entrepreneurial ambition, and entrepreneurial judgment. In contrast, managerial services relate mainly to the execution of entrepreneurial ideas and proposals and to the supervision of existing operations.

> "There are probably many ways of defining enterprise, but for our purposes it can usefully be treated as a psychological predisposition on the part of individuals to take a chance in the hope of gain, and, in particular, to commit effort and resources to speculative activity. The decision on the part of a firm to investigate the prospective profitability of expansion is an enterprising decision, in the sense that whenever expansion is neither pressing nor particularly obvious, a firm has the choice of continuing in its existing course or of expending effort and committing resources to the

> investigation of whether there are further opportunities of which it is not yet aware. This is a decision which depends on the 'enterprise' of the firm and not on sober calculations as to whether the investigation is likely to turn up enticing opportunities, for it is, in effect, the decision to make some calculations. This is truly the 'first' decision, and it is here that the 'spirit of enterprise', or a general entrepreneurial bias in favour of 'growth' has perhaps its greatest significance" (Penrose, 1959, p. 33).

However, Penrose recognizes that entrepreneurship is difficult to be incorporated into economic terms, and the way she deals with this issue is by providing a discussion of the different kinds of "entrepreneurial services" and by assuming the kind of firms her theory is concerned with are those ones possessing the relevant "entrepreneurial services or entrepreneurial qualities".

> "It is clear that this opportunity will be restricted to the extent to which a firm does not see opportunities for expansion, is unwilling to act upon them, or is unable to respond to them……but at the very least we have to assume that the firm is eager and willing to find opportunities and is not hindered in acting on them by 'abnormally' incompetent management. In other words the firms with which we shall be concerned are enterprising and process competent management; our analysis of the processes, possibilities, and direction of growth proceeds on the assumption that these qualities are present in the firm" (Penrose, 1959, p. 32).

That entrepreneurship as a premise for the firms with which the Penrose theory is concerned is also reflected in the discussion of entrepreneurial judgment:

> "….and content ourselves with the observation that firms whose entrepreneurs are not capable of reasonably 'sound' judgements do not come within the class of firms with which we are concerned. That there are firms who consistently make mistakes, over-estimate what they can do, guess wrongly the future course of events, no one can doubt, but they do not interest us here; no theory of growth will explain their actions—only a theory designed to explain 'mistakes' or failure"(Penrose, 1959, pp. 40-41).

The Penrose theory has made clear that entrepreneurship plays a crucial role in her theory, but the assumption that the Penrose theory is only concerned about firms that make sound entrepreneurial judgment may be arbitrary. It is unclear how exactly entrepreneurship works in her theory. The contemporary entrepreneurship literature has tended to move away from understanding entrepreneurship as the psychological traits of individual entrepreneurs (Davidsson and Wiklund, 2007). As the Penrose theory is to elicit the processes underlying firm growth, the role of entrepreneurship in Penrose theory could be improved by the integration of a process model of entrepreneurship (Baker and Nelson, 2005). The recent entrepreneurship literature has recognized that entrepreneurship is a process about how entrepreneurial opportunities are discovered, evaluated, and exploited (Venkataraman, 1997; Shane and Venkataraman, 2000; Moroz and Hindle, 2012), and how these processes are completed will have important influence on the entrepreneurial outcomes (Sarasvathy, 2001; Baker and Nelson, 2005). It might be more interesting to integrate the process by which firm resources are turned from homogenous inputs into heterogeneous outputs that generate profits into her theory (Alvarez and Busenitz, 2001). By doing so, a more sound “generative mechanism” behind the growth process might be achieved.

2.6.6. Existing Applications of Penrose Theory

The attention to Penrose theory, however, seems to be paid more to her unattended contribution to the Resource Based Theory, than her theory of firm growth (Lockett et al., 2011). Due to the same emphasis on firm resources, many studies equal the Penrose theory with the resource-based theory originating from Barney (1991). Although both the Penrose theory and the resource-based theory find the sources of advantage in growth from within the firms, and all to the firm resources, there exist notable differences between the two theories. The resource-based theory by Barney has the pivotal assumption of resource heterogeneity (Barney, 1991). For example, the RBV posits that under conditions of resource homogeneity, there will be no strategy that one firm could conceive of and implement that could not be similarly accomplished by the other firms. The Penrose theory, however, includes the explanation of how firms grow differently even under homogenous resource condition (Nason and Wiklund, 2015). This difference is caused by the fact that entrepreneurship constitutes an important element in the Penrose theory, while not seemingly in the RBV (Alvarez and Busenitz, 2001).

Although vast citations of Penrose theory could be found in the firm growth and resource based theory literature, existing studies mainly focus on investigating particular pieces of the dynamic growth mechanism in Penrose theory. For example, based on accumulated evidence on firm growth, Geroski (2005) has questioned the Penrose managerial effects may only have little discernible effects on the growth of firms. Lockett et al. (2011) point out that the application of Penrose's theory has typically been limited to a focus on the managerial limit and argue the same focus should be given to the productive opportunity set. They posit that organic firm growth will create homogeneous resources and hinder the expansion of the productive opportunity set. Their regression analysis with panel data over ten years shows that previous organic growth has negative influences on future organic growth. However, the constructs of managerial limit and productive opportunity set do not appear in their regression model.

Gruber, MacMillan and Thompson (2008) focus on the concept of Penrose productive opportunity set of firms and find that the number of opportunities increases the possibility of choosing the most favourable opportunity and entrepreneurs who could identify a larger number of opportunities prior to market entry could create ventures that are more successful. The beneficial effect of the size of the productive opportunity set, however, is subject to diminishing marginal return, because of the associated search costs and resources for opportunity evaluation and exploitation. Gruber, MacMillan and Thompson (2012) further investigate how the firm founders' pre-existing knowledge and experience will affect the construction of emerging technology firms' productive opportunity set. While these studies have improved our understanding of Penrose theory, an issue common to these studies is that these studies are using static research methods to investigate dynamic phenomenon and variance research designs to examine process theory.

In the foreword to the Penrose's book of the theory of firm growth process, Martin Slater comments that the Penrose theory does not provide or does not even attempt to provide an integrated analytical model of firm growth. However, the pattern of thoughts inherent in Penrose theory makes the construction of such a model possible.

The consequence of this lack of an explicit analytical model in the Penrose theory is that the majority of studies claiming using the Penrose theory focus on certain pieces of the theory related to the scholars' area of research or the most salient piece of the theory, while ignoring the other parts—the problem that most classics suffer. This negligence is understandable given that the Penrose theory consists of a cluster of ideas and dynamic processes, while scholars in the business and management studies are trained mainly with static variance approaches. One of the potential reasons for Penrose's not offering a ready-made model, the author of this study suspects, is that the simplification unavoidably induced in the modelling process will compromise the richness of her theory.

2.7. Summary

In summary, EO is one of the concepts in existence to help us understand entrepreneurship within firms. With a root in the strategy making process, the concept of EO was originally meant to characterize and distinguish key entrepreneurial processes within firms. Despite the wide use of the EO concept in entrepreneurship studies, it remains unclear how EO works to depict the entrepreneurial processes within firms, and subsequently, how will it lead to firm growth.

A major discussion ongoing in the EO literature relates to the dimensionality of EO. While some studies posit that only firms that score highly in all three dimensions of EO could be considered as entrepreneurial, other studies are of the view that firms of any effective combination of the EO dimensions could be regarded as entrepreneurial. This discussion has been exclusively framed under the variance-based research, in the form of discussing whether EO is a formative or a reflective construct. What new insights could we gain if investigating EO using a process approach? To the best of the author's knowledge, there has not been any study employing a process approach to investigate EO yet.

A great deal of effort has been devoted to understanding the relationship between EO and firm growth, with findings suggesting that the relationship could be positive, negative, inverted-U shape, variance enhancing instead of mean enhancing, or no significant relation at all. Two factors could be causing these mixing results. Firstly, due to the challenge in obtaining longitudinal data, empirical studies typically use data at one or two time points. However, firms usually do not grow in a linear fashion.

Things could go better before going worse or go worse before going better. Results from growth data at two time points may not reveal the true effect of EO on firm growth. Secondly, whether it is under the unidimensional view or the multi-dimensional view of EO, there is no denying that there could be interaction effects among the EO dimensions on firm growth. Examining the EO-firm growth relation without regard to the synergy among the dimensions of EO may lead to dubious results.

Both the entrepreneurial process and the firm growth process have been shown to be nonlinear process characterized by discontinuous changes. This requires a process approach to understand how things develop and change over time. Two kinds of process approach exist. The common approach used in the literature is to capture the sequence of events that unfold over time. The second and less used approach is to investigate the underlying "motor" or "mechanism" behind the sequence of events. Far less research has gone beyond the surface sequence of events to identify the underlying mechanism driving these events. This study aims to figure out the underlying mechanism behind the different growth trajectories of firms. As Penrose says "Accordingly, a theory purporting to explain the process of growth of firms can be useful on two levels. It can be useful even if it only presents a logical model yielding conclusions which seem to correspond to actual events that can be 'observed' in the growth of actual firms. But it will be even better if it helps us to understand the actions behind these events." (Penrose, 1959, p. 26).

Among the different theories of firm growth, the Penrose theory distinguishes itself by eliciting the underlying process mechanism driving firm growth. Entrepreneurship plays an important role in Penrose theory. However, there is no process model of entrepreneurship in Penrose theory (Baker and Nelson, 2005). This study therefore aims to investigate how entrepreneurial orientation and the Penrose theory work together to elicit the underlying mechanism behind firm growth.

Lastly, the Penrose theory's contribution to the resource-based theory, and to the firm growth and strategy management field has been acknowledged. The widespread use of Penrose, however, only reveals the examination of certain pieces of Penrose theory. There has not been a systematic examination of the dynamic process mechanism in the Penrose theory.

Chapter 3. Research Method

3.1. Computer Simulation Method for Theory Development

As this study investigates dynamically unfolding processes, computer simulation is employed to gain insights into the complex theoretical relationships among the core constructs. Computer simulation has gained increasing importance in theory development in strategy and organization studies, and actually, some influential theories were developed using simulation method (Cohen, March and Olsen, 1972; March, 1991; Levinthal and Posen, 2000). Simulation enables researchers to specify complex theoretical relationships and generate dynamic hypotheses that cannot be developed using case studies or deductive theory reasoning (Chirico et al., 2012). In theoretical development, computer simulation particularly means first creating a computational representation of the underlying theoretical logic that links theoretical constructs together. This representation is then run by using simulation software under varying experimental conditions, usually by varying the assumptions and construct values, to gain new insights into the theory (Davis, Eisenhardt and Bingham, 2007).

Computer simulation methods have some advantages over traditionally used methods in theory development. Firstly, by translating dynamic processes into formal models we could spot the logical inconsistencies in existing theories (Rahmandad and Repenning, 2016). This process of formalizing theories also helps us discover the ideology and bias, and improve our understanding of theoretical assumptions, boundaries, as well as dynamic hypothesis (Sterman, 2000). All these aspects will help enforce theoretical precision and enhance the internal validity of the theory. Secondly, many organizational theories are actually dynamic in nature, but the limitation in human cognition and the limitation in traditionally used statistical models effectively prevent us from drawing correct inferences from dynamic theories. In this respect, simulation could inform us of the dynamical implications of multiple underlying organizational or strategic processes as they unfold over time. This effectively helps extend the current theory (Rudolph and Repenning, 2002). Computer simulation methods are particularly suitable for the study of theories in which the basic processes are well known, but the interactions of these processes are only at best vaguely understood (Davis, Eisenhardt and Bingham, 2007). This applies for the study of the entrepreneurial process, where the basic unfolding of the process is recognized, but the interactions and complexities among its sub-processes remain unclear. Thirdly, computer simulation is powerful at experimentation (Davis, Eisenhardt and Bingham, 2007), through which new testable propositions beyond the theory are derived. More often, experimentation in real life settings is either infeasible or too costly. One of the key advantages of computer simulation method lies in enabling researchers to eliminate the effects of confounding factors and to conduct an extensive set of experiments quickly and at almost no cost.

Despite these strengths, the usefulness and value of computer simulation method have been under scrutiny of business and management scholars. The most criticized disadvantage of simulation is the lack of reality, as a model is just a very simplified representation of reality, usually based on some unrealistic assumptions. The results from simulation are thus believed to be unbelievable. However, the problem of external validity is not unique to the simulation method, but inherent in almost any kind of research methods. No model is truly capable of replicating the reality in full detail. Even if it is, it is not worthwhile doing so. The popularity of statistical methods in business and management discipline is not because the results from statistical models have more validity over those gained through simulation methods, but probably more because grasping the computer simulation method usually requires a certain degree of mathematical and computational knowledge, which are usually not available in the training programs of business school.

There is a variety of computer simulation methods, such as agent-based modelling, stochastic modelling, system dynamics, and discrete event modelling. Each approach has its modelling tools and its intrinsic theoretical logic. Choosing the appropriate approach should be dependent on the fit between the research question at hand and the assumptions and theoretical logic of the simulation approach. Davis, Eisenhardt and Bingham (2007) offer an exciting roadmap about how to develop new theory using computer simulation methods and how to choose the appropriate simulation method. This study adopts the System Dynamics (SD) modelling approach. The SD method typically models systems consisting of circular causality and time delays. This is particularly suitable as the core process of firm growth in Penrose theory is the dynamic feedback growth process.

3.2. The System Dynamics Simulation Method

System dynamics is a modelling technique to frame and understand the nonlinear behaviour of complex systems over time using tools of stocks, flows, internal feedback loops, and time delays (Sterman, 2000). This method originated in MIT around the1950s by Professor Jay Forrester, intending to understand the success and failure of businesses using science and engineering knowledge. The famous ‘The Limits to Growth’ model developed using system dynamics method in the 1970s has attracted a lot of attention through its prediction of the economic collapse in the 21 century. In the recent decades, the system dynamics method has developed and gained wide applications into various areas of study for policy design and policy test, such as corporate policy, health care studies, population studies, environment and energy studies, and so forth. The following provides an explanation of some of the key concepts of this method:

System thinking: In understanding the system dynamics method, the term ‘system’ refers to a collection of elements interacting with each other to form a whole, while the term ‘dynamics’ means changes over time. If something is dynamic, it is constantly changing. A dynamic system is therefore a system in which its components interact with each other to stimulate changes over time and the system dynamics is a methodology used to understand how systems change over time.

In the business and management disciplines, the commonly used models are linear models. Linear models usually could only accommodate a limited number of variables, with many important causal relationships omitted. In linear models, cause-effect relationships go only in one direction, from the independent variables to the dependent variable. This linear thinking is common in daily life. For example, the heavy snow in recent days brought down the room temperature, which caused me to put on more clothes. This cause-effect relation is direct and in order. The delay between the temperature drop and my action of putting on more clothes is out of consideration and that my action of putting on more clothes does not re-affect the room temperature. This direct and one-way cause-effect relation in linear models is well suited for the human cognition, but this simplicity is inadequate to capture the complexity of reality. It is easy to go unnoticed that we are all located in a system, although the boundary of which is fluid sometimes. The real-world phenomenon is usually closed-loop system with circular chains of causality and high complexity.

In linear thinking, the independent variables cannot correlate with each other. The system thinking, on the contrary, stresses the dynamic complexity of a system. It recognizes how the system components are connected, i.e. system structure, as important as the components themselves in affecting system behaviour. For example, the University of Bath is reputational for students' satisfaction. Considering the heavy snow, the university decided to provide heating for student accommodations 24 hours per day. The heating then effectively raised our room temperature. In this situation, the fall in room temperature causes actions of other system agents to take action to push the room temperature back to its initial level.

System elements are always connected with each other in complicated and unexpected ways, creating changes and chaos in system behaviour. Professor Jay Forrester helped solve Generic Electric Corporation executive's puzzle that the fluctuations in their production, inventories, employment, and revenue were not due to the exogenous forces, but due to the internal structure of their firm. The key to understanding policy resistance and counterintuitive behaviour lies in understanding the structure and interactions among the agents. One fundamental assumption of the SD method is that the system structure determines system behaviour. Even a system with a few elements could generate highly complex and dysfunctional behaviour. System thinking helps us understand counterintuitive behaviours and get to the root causes of the problem.

The move from linear understanding to system thinking propels us to rethink the cause and effect relation. In linear thinking, the relation between cause and effect is direct and final, that is, single cause. The time delay in which the effect takes place is out of consideration and researchers do not dig into what causes the cause. This is "open loop" thinking—the output of a system is the outcome of the input, but has no bearing on the input. In a complex system, the effect is often distanced from the cause in time and in space. Under the closed loop thinking, each variable is usually both the cause and the effect.

The linear thinking is static in that there is a clear ending to the effect. For example, the action that I put on more clothes marks the end of the story. In the absence of external forces, the system is thought to stay unchanged. Under the closed loop system thinking, the system components' actions create results that redefine the situation we face, which changes our evaluation of the problems and alters the actions that we take tomorrow. For example, continuing my story, the heating was very effective to improve the room temperature, but it had the side effect of dehydrating the human body. My immunity to virus was reduced due to the long dehydration at night and then caught a cold. In this case, my catching a cold was not directly caused by the snow, but indirectly by the goodwill of the university in response to the snow. I then had no other choice but to turn down the heating to recover. The room temperature then fell again. This simple example is to show that even in the absence of external forces, the interactions among the system components could create new situations and cause the system to change over time.

Feedback is the process through which changes in something, typically after a delay, affect itself again through a chain of causal relations. There are two kinds of feedback loops: the positive feedback loop (or reinforcing feedback loop) and the negative feedback loop (or balancing feedback loop). The feedback is positive if an increase in this variable leads to a further increase in the variable. The feedback is negative if an initial increase in a variable, after a delay, leads to a decrease in the variable. Figure 3.1 shows examples of the simplistic positive and negative feedback loops. In Figure 3.1, the increase in variable X leads to an increase in variable Y; the increase in variable Y in turn leads to a further increase in variable X. Through this feedback process, the increase in variable X leads to a further increase in itself.

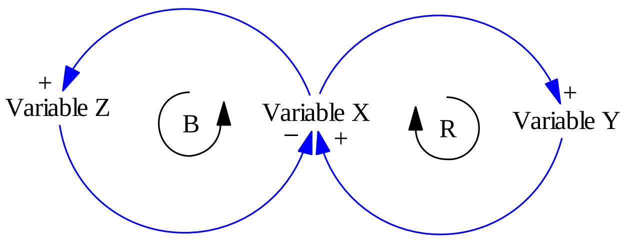


Figure 3.1 Positive and negative feedback loops

Positive feedback is a reinforcing and compounding process, where any small deviations from the system equilibrium will be amplified. We could understand this kind of feedback loop through the Bible Matthew effect "For to everyone who has will more be given, and he will have abundance; but from him who has not, even what he has will be taken away." The existence of this effect actually demonstrates us the power of accumulated advantage, such as the capital or advantage of established firms.

In the absence of any other offsetting effects, the reinforcing feedback loop could drive the system status to indefinitely ever greater. The typical behaviour created in a system dominated by positive feedback loops is exponential growth. However, reinforcing processes normally cannot continue forever. There are always some factors, internal or external to the system, that present as limitations to the system's growth. The presence of these limiting factors constraining reinforcing feedback loops is usually named as the limits to growth (Meadows, 2014).

In contrast, negative feedback balances and stabilizes systems. In Figure 3.1, the increase in variable X leads to an increase in variable Z; the increase in variable Z, however, results in a decrease in variable X. Through this feedback process, any small deviation in system behaviour from its original status is counteracted. The negative feedback loops, therefore, drive a system towards stability. In the understanding of feedback loops, it is important to recognize that the reinforcing feedback loop, although addressed as "positive" feedback loops, does not mean that it will always be beneficial for a system. In a similar vein, it does not mean that the negative feedback loops will be bad for the system's growth.

A complex system usually consists of multiple feedback loops, either positive or negative. These feedback loops simultaneously play their roles, although their strength could be different. The system's behaviour is largely determined by the relative dominance or strength of these different feedback loops. The strength of these feedback loops, on the other hand, could also change over time as the system evolves.

Stock-flow structure: Another fundamental tool of the SD method is the stock-flow structure. The stock-flow structure builds on the principle of accumulation, the process of which is critical to the dynamic behaviours of a system. The SD method uses stock and flow structure to represent changes. A good example to help us understand this stock-flow structure is the bathtub, where the bathtub represents a stock, the tap represents the inflow to the bathtub, and the drain represents the outflow to the bathtub. The bathtub stock is filled by the tap and decreased by the drain. At any point in time, the stock of water in the bathtub is the accumulation of what has flowed in from the tap, minus what has flowed out through the drain. The current level of water in the bathtub represents the status of the system—based on this information we make decisions on whether to turn the tap or the drain wider or turn them off, etc.

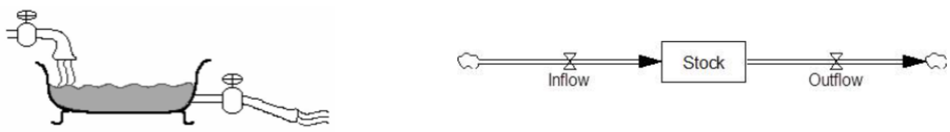


Figure 3.2 Stock and flow strucutre

Stock variables are represented as rectangles in the diagram. One often neglected or underestimated key characteristic of stock is that stock has memory and could create inertia in a system. Stocks are accumulations that cannot change instantaneously—they change gradually over a period. For example, when shutting off the faucet, the accumulated water in the bathtub will not immediately disappear. Flows represent the rate of change in stock variables. Flow variables are represented as valves in the diagram. Flow variables could be further classified into two categories: inflow variables and outflow variables. An inflow variable represents the increase in the corresponding stock variable and an outflow variable represents the rate of decrease in the stock variable. In the bathtub example, the inflow rate is the rate through which water comes in from the tap and the outflow rate is the rate through which water goes out from the drain. Inflow and outflow work together to determine the dynamic changes in the stock. In the system dynamics modelling, stocks could only be changed by flows. This modelling requirement is a reflection of the above-mentioned characteristic of stock that changes in stock are not immediate but take time.

This distinction between stock and flow variables enables us to consider the processes of changes in entities, which are often neglected in the regression model. The distinction between inflow and outflow variables further enables us to study separately the decision-making process that influences the inflow and that influences the outflow to the stock.

Time delay: In most cases effect takes time to occur. The longer the delay between a cause and its effect, the less likely the policy maker will detect this association. Time delay actually often plays a significant role in altering system behaviour, which has also been generally ignored or underestimated in statistical models. System Dynamics method enables researchers to understand the dynamic implications of time delay.

Variables in SD models are generally classified into five categories: stock variable, flow variable, auxiliary variable, constants (or parameters), exogenously changing parameters.

Auxiliary variable—The auxiliary variable is an intermediate concept to aid clarity. It is a mathematical function of stocks. Auxiliary variables could always be eliminated, rendering the model only consisting of stocks and flows. However, eliminating auxiliary variables could cause a reduction in the clarity of theoretical logic in the system.

Parameters or constants are the same constants that we meet in statistical models, the values of which remain unchanged over the course of the simulation.

Exogenously changing parameters are parameters, the values of which are changing in a specific way as the researcher specifies. This means the value of the parameter is not unchanged over the course of the simulation, but the way it changes is predefined before the start of the simulation.

Clouds: As shown in Figure 3.2, there are two clouds, one connected with the inflow and the other connected with the outflow. There must be somewhere from which the flows come and somewhere into which the flows eventually go. However, not all the time we care about where they come from or where they go into. If we care about that, we would use stocks to represent the places where the flows come from or where they go into. However, if not, we use clouds instead. The clouds therefore represent the boundary of the system, i.e. where it comes from or where it goes into is something we do not care.

Arrows: As will be shown in the model in Figure 4.1, there are arrows connecting the different variables. These arrows represent causal relationships, rather than correlations.

The human mind has limited capacity in understanding and predicting even the simplest systems with higher order differential equations, even if we were given complete information on the system relationships and parameters. Computers could inform us of the behaviour of complex systems with great precision and speed, and help us identify the highly leveraged policy points. Furthermore, to make policy changes we usually need to know the consequences of the decisions that have never been tried for. In many situations, controlled experiments are either impossible or too costly to implement in real life. Computer simulations are usually required to aid us in understanding model behaviour.

System Dynamics simulation method has long been applied to the study of design, execution, as well as dynamics of effective research and development (R&D) process and new product development processes. Repenning (2000) employs the SD method to understand why firms always divert from the desired mode of process execution from the point of view of resource allocation among multi-projects. Van Oorschot, Langerak and Sengupta (2011) adopt the SD method to examine the effectiveness of different intervention heuristics among development time, cost and product performance, during the new product development process.

The SD method also gains good application in the strategy and organization literature. Rahmandad and Repenning (2016) develop a system dynamics model to represent the mechanism underlying capability erosion dynamics. Through experimentation, they identify a set of testable conditions under which this mechanism is likely to exist. Rudolph, Morrison and Carroll (2009) combine the sensemaking and decision making literature to create a system dynamics model to represent the mechanism behind action-oriented problem solving. Their model reproduces the four types of problem-solving behaviours found in a previous empirical study. Through further experimentation, they find out the boundary conditions for the four types of problem-solving pattern and based on these experimental results, they come up with new hypotheses.

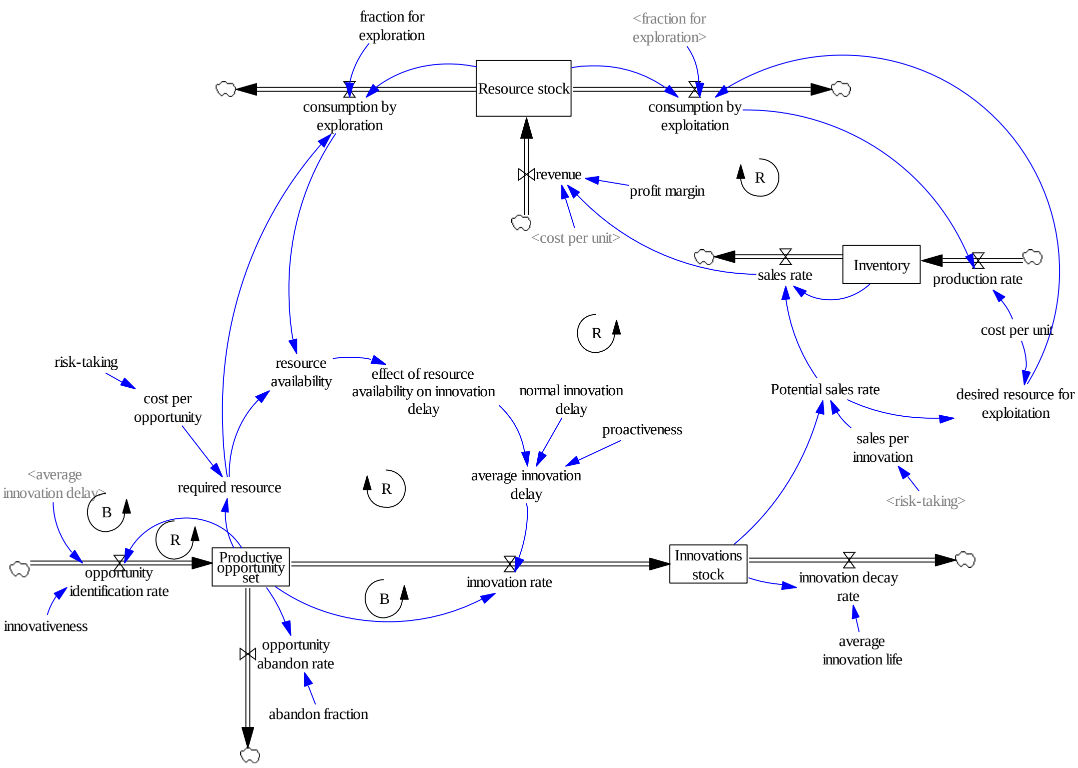
Chirico et al. (2012) seek to understand how paternalism in family businesses influences firm social capital, dynamic capability and value creation in a circular chain over time. Drawing existing literature, they develop a SD model to represent the theoretical mechanism and to understand its dynamic implications. Based on the simulation results, they come up with new propositions that might guide future research. Drawing on system dynamics modelling, Walrave, van Oorschot and Romme (2011) develop a process theory about how the interplay among top managers, board members and exploration-exploitation activities get firms trapped in the suppression of exploration activities. Rudolph, Morrison and Carroll (2009) induce a formal system dynamics model from existing empirical studies and based on simulations from this model they develop a theory about the mechanisms that produce variations in diagnostic problem-solving.

The SD method could also accommodate randomness. It should be doubtless that the entrepreneurial process is anything but deterministic process. The model built in this study, as will be illustrated in the next chapter, contains stochastic elements. To understand the outcome in the presence of randomness, this study employs Monte Carlo simulation. Monte Carlo simulation is a method that is widely used to address problems that embed probabilistic interpretation. Principle of this method is to use the technique of repeated sampling from predefined random probability distribution to get the results out of hundreds or thousands of runs and summarize the results in a statistical way.

Chapter 4. Model Structure

The SD model in this study is developed by translating the theoretical constructs and relationships in the entrepreneurial orientation and firm growth literature into the System Dynamics language of stock-flows, time delays, and feedback loops. After that, I iteratively revised the model by drawing on other relevant literature—entrepreneurship, innovation, and firm growth. The variables and linkages that comprise these processes are well established in the literature, but taken together they provide a new, dynamic view of the firm growth process. This modelling process is very helpful in terms of understanding the structure and interactions among different elements in a system. Values of model parameters were assigned by drawing on existing studies and empirical dataset. The systematic configurations of parameters were simulated across a large number of experimental model runs. To build confidence in the robustness of the simulation results, extensive extreme condition tests and sensitivity analysis were performed. Figure 4.1 is an illustration of the overall model.

Figure 4.1 Overall model structure



4.1. Entrepreneurial Processes within Firms

In contemporary entrepreneurship research, the concept of entrepreneurial opportunity has become a central construct for articulating the direction of entrepreneurial development (Venkataraman, 1997; Shane and Venkataraman, 2000). With the increasing recognition that entrepreneurial processes generally involve processes of opportunity identification and exploitation (Shane and Venkataraman, 2000), much scholar effort has been devoted to understanding questions such as what is an entrepreneurial opportunity (Dimov, 2007; Short et al., 2009; Dimov, 2011; Davidsson, 2015), how to identify it (Gruber, MacMillan and Thompson, 2012, 2013), and how to make opportunity exploitation decisions (Choi and Shepherd, 2004; De Jong, 2013). However, it remains unclear how these distinct processes are interlinked with each other into a holistic and coherent process model. In a review of existing entrepreneurial process models, Moroz and Hindle (2012) conclude that extant entrepreneurial process models remain largely fragmented, and they call for the construction of a single harmonized entrepreneurial process model.

4.1.1. Opportunity Identification and Exploitation Process as Interdependent Feedback Processes

As opportunity exploitation takes time, the productive opportunity set accumulates those identified opportunities that are under exploitation. Thus, the productive opportunity set is modelled as a stock variable. It is increased by the opportunity identification rate and decreased by innovation rate and opportunity abandon rate.

The arrow from the productive opportunity set to the opportunity identification rate represents the idea that opportunity exploitation process leads to the identification of new entrepreneurial opportunities. This modelling is first inspired by the Penrose theory that the opportunity exploitation process results in the acquisition and generation of new knowledge, which leads to new insights on the recombination of firm resources and new productive opportunities. This insight by Penrose finds clear support in entrepreneurship studies, where knowledge has been acknowledged to play a pivotal role in the identification of entrepreneurial opportunities (Shane, 2000; Drucker, 2002; Patel and Fiet, 2011; Hill, 2014) and that entrepreneurial opportunity exploitation process leads to new knowledge generation is indicated in multiple theoretical perspectives of entrepreneurship.

Entrepreneurship has been considered as a learning process where firms acquire new knowledge by exploring into the unknown, by observing the action—outcome relation, and by trial-and-error (March, 1991; Cope, 2005; Parker, 2006). Firms also conduct extensive search for new external knowledge to integrate with its internal knowledge in attempt to solve problems in entrepreneurial conditions of ambiguity (Katila and Ahuja, 2002). The knowledge gained by learning and the improved ability of knowledge integration and application all facilitate the recognition of new opportunities (Lumpkin and Lichtenstein, 2005). In addition, in the theories of entrepreneurial action, entrepreneurial opportunity is considered as an important driver of entrepreneurial action, while the novelty and uncertainty intrinsic to entrepreneurial action spur the creation of new ideas through exploiting contingencies and creatively combining what is at hand (Sarasvathy, 2001; Baker and Nelson, 2005; McMullen and Shepherd, 2006). Furthermore, the interplay between opportunity exploitation process and opportunity identification process is also indicated by the sense-making literature where new alternatives to problem solving are being cultivated as firms complete actions and interpret the emerged new information (Rudolph, Morrison and Carroll, 2009). Lastly, this arrow from the productive opportunity set to the opportunity identification rate also resonates with the recombination theory that innovative ideas often come from the recombination of existing ideas (Fleming, 2001; Kaplan and Vakili, 2015).

This link completes a feedback loop between the productive opportunity set and the opportunity identification rate: the more opportunities the firm exploits, the more opportunities it could identify, which in turn causes more opportunities to accumulate in the productive opportunity set. In the absence of any other offsetting influences, this loop pushes the productive opportunity set of the firm towards ever greater.

The modelling of innovativeness: The presence of innovativeness is supposed to be a determining factor in the firm's ability to generate new ideas as well as its willingness to commit resources into the identified opportunities, because innovativeness "represents a firm's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes" (Lumpkin and Dess, 1996, p. 142). Here innovativeness is modelled as the degree of firm's ability to generate new resource combination ideas and its willingness to invest resources into the identified opportunities in order to turn the opportunity from a concept into a concrete product or service.

This modelling resonates with the notion that innovativeness incorporates two stages: the generation of new ideas and the active implementation of new ideas, processes, or activities (Hurley and Hult, 1998), and is consistent with the empirical research that usually operationalizes innovativeness through the human or financial resources invested into innovative activities (Lumpkin and Dess, 1996). The effect of innovativeness on opportunity identification rate is positive, and its effect is captured in a mathematical function, of which the first and second derivatives are both positive.

The opportunity abandon rate: Not all identified opportunities will be exploited (Haynie, Shepherd and McMullen, 2009). An opportunity will not be an opportunity forever (Eckhardt and Shane, 2003). Entrepreneurial opportunities may become "obsolete" after a period of time, especially in a rapidly changing environment (Edelman and Yli-Renko, 2010). Even under the condition of no environmental change, firms' perception about the opportunity may also change over time, making some opportunities undesirable any longer (Tumasjan, Welpe and Spörrle, 2013). The uncertain environment also sometimes requires firms to terminate projects that do not meet the expectations and release the resources commitments (Klingebiel and Rammer, 2014; Behrens and Patzelt, 2016). An outflow "opportunity abandon rate" is added to the productive opportunity set to represent this phenomenon. This opportunity abandon rate is mathematically depicted as a first-order decay formulation.

The innovation rate: The variable "innovation rate" represents the rate at which firms develop new products, services, or processes. The productive opportunity set coupled with the time horizon over which the exploitation completes, i.e. the delay in innovation, gives rise to the innovation rate. With the number of opportunities in the productive opportunity set accumulating, the innovation rate also rises. The firm's innovation rate is also affected by its "average innovation delay".

The variable 'average innovation delay' represents the time elapsed from the moment when the exploitation starts to the moment when the new product or process is fully developed for market introduction. The average innovation delay variable is a function of three factors: the normal innovation delay, the resource availability for developing a new project, and the degree of proactiveness of the firm. The normal innovation delay parameter represents the average duration of opportunity exploitation at the industry level.

The resource availability variable: The productive opportunity set along with the resource required per opportunity gives rise to the required resource variable. The auxiliary variable "resource availability" is the ratio between the resource available for new projects development and the resource required for new projects development. A negative relation between the resource availability and the average innovation delay is conceived in the model because empirical studies in new product development have found a positive relationship between resource adequacy and innovation speed (Deeds and Hill, 1996; Weiss, Hoegl and Gibbert, 2017).

The modelling of proactiveness: Proactiveness is modelled through its effect on innovation delay, where the more proactive the firm is, the quicker the entrepreneurial process unfolds. This modelling relates to the definition that proactive firms are constantly monitoring the environment, taking initiatives when opportunities emerge, and being quick to market (Miller, 1983; Lumpkin and Dess, 1996).

The arrows from the productive opportunity set to resource availability, and then to innovation delay form two feedback loops: the reinforcing innovation delay loop and the balancing opportunity identification loop.

The reinforcing innovation delay loop is a reinforcing loop, labelled with an R. This loop denotes the process that the more opportunities accumulated in the productive opportunity set, the more resources will be required, and the lower the resource availability for the entrepreneurial process becomes. The decline in the resource availability leads to a decrease in innovation rate, which in turn causes more opportunities to accumulate in the productive opportunity set and leads to even more resource demands. When this reinforcing innovation delay loop works in this direction, it is a vicious circle causing ever-increasing innovation delay and falling firm innovation rate.

The balancing opportunity identification loop is a balancing loop, labelled with a B. The process of identifying new opportunities takes time. The rate of identifying new opportunities depends on how quickly the opportunity exploitation completes, as expressed as the arrow from innovation delay to opportunity identification rate in the model. The opportunity identification rate increases the productive opportunity set, which leads to increased resource requirement, decreased resource availability, and increased innovation delay. The increase in innovation delay, in turn, causes the opportunity identification rate to fall. This self-regulating mechanism is consistent with the empirical findings that firm resource condition plays an important role in the timing of initializing opportunity exploitation (Choi and Shepherd, 2004).

4.1.2. Exploited Opportunities Create Demands and Decay

Once an entrepreneurial opportunity is developed into a concrete product or service, it comes out of the productive opportunity set and enters into the innovations stock. The innovations stock represents all exploited opportunities that are valid in creating demand. The exploited opportunity, i.e. the innovation, cannot work to create demand forever. This may be due to Schumpeter’s creative destruction caused by the introduction of new products, or increased competition from new entrants, or simply because changing conditions render the innovation undesirable to the customers any longer. To represent this phenomenon, I add an outflow to the innovations stock and name it as the “innovation decay rate”. The innovation decay rate represents the rate at which existing innovations cease creating firm demand. The parameter "average innovation life" denotes the length of time when the innovation is an innovation, which resonates with the concept of "product life cycle". The innovations stock is increased by the innovation rate and decreased by the innovation decay rate.

To model the entrepreneurial outcome, it is assumed that each exploited opportunity could create a certain unit of sales, i.e. the variable "sales per innovation". This actually mirrors one of the core processes in the Penrose theory through which firm demand is "created". One defining characteristic of the entrepreneurial process is the risk involved in resource commitments. Research has shown that the returns to the entrepreneurial process are highly skewed (Coad and Rao, 2008; Crawford et al., 2015). In this study, the "sales per innovation" variable is modelled as a random variable conforming to lognormal distribution.

The modelling of risk-taking: As central to the entrepreneurial process, the characteristics of entrepreneurial opportunities play an important role in how the entrepreneurial process unfolds as well as how it ends (Shane and Venkataraman, 2000). Indeed, an important question for firms to consider before embarking the entrepreneurial process is what kind of entrepreneurial opportunities they would like to pursue. Studies on rule-based reasoning for opportunity evaluation has suggested the future expected financial return and the potential magnitude of loss, i.e. the worst case scenario, of the opportunity as two important judgment rules applied in discerning the attractiveness of an opportunity (Wood and Williams, 2014; Williams and Wood, 2015). Studies on opportunity evaluation decision using resource-based theory also show future resource payoff of the opportunity and existing resource endowment of the firm as central factors in making opportunity exploitation decision (Haynie, Shepherd and McMullen, 2009).

As the chance to gain high economic payoffs usually comes at the expense of high riskiness in investment (Dencker and Gruber, 2014), firm's attitude towards risk and uncertainty therefore plays an important role in determining the kind of opportunities the firm engage with and the payoff distribution it will have. The significance and variability of the potential losses and returns are the most salient considerations for decision making under the risky entrepreneurial context where there is a real possibility of losses (Forlani and Mullins, 2000). Highly risk-taking firms favour opportunities that will bring huge future gain although they may incur heavy resource commitments (Lumpkin and Dess, 1996).

Drawing on the literature, the effect of risk-taking is modelled in two aspects of the model‒the resource cost per opportunity and the variance of the random distribution for sales per month variable. Risk-taking is modelled in such a way that the higher the risk-taking, the higher the resource commitment incurred by each opportunity and the bigger the standard deviation of the random distribution of the sales per innovation variable. This modelling of risk-taking is concurrent with the distinction between risk-taking and uncertainty: that under risky conditions the distribution of the probable outcomes for different actions is known.

The normal random functions generate random numbers in every time step and that the successive random values generated each time are independent. This sampling is quite frequent and that this means that history does not matter—the values that have come before have no effect on the next value. This assumption that random values being frequent and independent does not hold in the real world, because luck cannot change infinitely fast. This study adopts the Pink noise structure, that is, "realistic noise processes with persistence", in the formula of the sales per innovation variable in order to produce inertia in the random values—the next random value is not independent but depends in some fashion on the previous values generated (Sterman, 2000).

4.2. Firm Growth as a Self-Reinforcing Process

Consistent with the Penrose theory and some existing research, this study considers firm growth as the change in firms' resource stock (Penrose, 1959; Eshima and Anderson, 2017). The resource stock is modelled as a stock variable as it accumulates the difference between resource consumption and resource generation over time.

After the new product, process or service is developed, the firm then launches it into the market for revenue. There exists a time delay between the time when the innovation is developed and the time when the innovation is in the market. To represent this mass manufacturing and shipping process, this study adopts the inventory structure with simple first-order delay (Sterman, 2000). Firms devote resources into manufacturing and shipping the product into the market to capture the demand created by the innovation. The process from firm resources to productive opportunities, then to developed innovations, finally back to firm resources forms a reinforcing firm growth loop. This reinforcing firm growth process is echoed in Danneels (2002), which finds a dynamically reciprocal interplay between product innovation and firm resources through field study. This positive firm growth loop has also been indicated in the firm growth as autocorrelated process literature—firm growth rate is positively influenced by its growth in preceding time (Ijiri and Simon, 1964, 1967; Bottazzi and Secchi, 2003, 2006).

If the firm resource stock increases, more resources will be available to fund entrepreneurial activities, the resource availability for entrepreneurial activities therefore increases. This leads to an increase in the innovation rate and subsequently increase in the number of demand creating innovations in the innovations stock. The increase in resource stock also leads to an increase in the resources available for exploiting the demands created by the innovations, thus leading to an increase in firm sales rate and firm revenue. The firm resource stock in turn increases further. In this situation, this reinforcing firm growth loop works as a virtuous cycle driving firms to grow more. In contrast, however, if the resource stock drops, the firm will have fewer resources available to invest into the exploration of new resource recombinations or into the exploitation of potential demands created by existing innovations. This will lead to falling firm sales and revenue, the resource stock therefore drops further. Firm in turn will have fewer resources available for exploration activities as well as fewer resources for capturing the demands created by its innovations. This cycle then repeats itself. When operating in this direction, the reinforcing firm growth loop manifests itself as a vicious cycle driving firms to decline.

As can be seen, the firm resource is consumed in two ways—through the firm's engagement with exploration activities and with exploitation activities. Exploration here means 'the identification and development of new products, processes, or services', while exploitation here refers to 'capturing value from developed innovations'. This study assumes that firms adopt a static proportional resource allocation policy between the exploration and exploitation activities.

The rate of resource consumption by exploration is the minimum of the required resource for exploration activities and the resource available for exploration activities. Similarly, the rate of resource consumption by exploitation is the minimum of the desired resource for exploitation activities and the resource available for exploitation activities.

4.3. Model Assumptions

Every model is built on some assumptions. The main assumptions underlying the model are as follows:

Firstly, the model is developed by assuming that there is no external constraint of opportunity supply in the environment. As long as the firm commits efforts into opportunity identification, there will always be opportunity to identify. This assumption is out of the consideration that the Penrose theory's focus is on how the firms' internal resources motivate and constrain firm growth, rather than the external environment.

Studies on the environmental conditions argue that the external environment confers firms the availability of opportunities and resources, and thus has a large bearing on firm growth (Eisenhardt and Schoonhoven, 1990; Rosenbusch, Rauch and Bausch, 2013). Factors such as technological change, industry structure, customer preferences change, could create different availabilities of growth opportunities (Drucker, 2002). In this vein, some studies have modelled firms as growing in a market with a finite number of growth opportunities (Bottazzi and Secchi, 2003).

This argument has been under the influence of the discovery view of entrepreneurial opportunity (Alvarez and Barney, 2007), which maintains that entrepreneurial opportunities exist objectively in the environment and independently of the entrepreneurs' actions. But where does the environment come from? How do the different environmental conditions and therefore the opportunities within come into place? Enterprises play a key role in the processes through which new technological changes and environmental conditions are formed (Walrave and Raven, 2016). The industry environment is gradually built up through the firms' joint behaviour of identifying and exploiting new resource combination possibilities (Aldrich, 1999).

The creation view of opportunity posits that the environment is enacted by the entrepreneurs' actions and it is the entrepreneurs' perception of opportunity and resources that determine entrepreneurial actions, rather than the objective environment

(Edelman and Yli-Renko, 2010). In the Penrose theory, productive opportunities are subjective opportunities that embed what the firm thinks it could accomplish.

"Firms not only alter the environmental conditions necessary for the success of their actions, but, even more important, they know that they can alter them and that the environment is not independent of their own activities. Therefore, except within very broad limits, one cannot adequately explain the behaviour of firms or predict the likelihood of success merely by examining the nature of environmental conditions. " (Penrose, 1959, p. 42).

The relationship between the objective environment and the subjectively perceived opportunities has not been made very clear under the creation view of opportunity (Edelman and Yli-Renko, 2010). This study does not attempt to deny the role of the environment in the entrepreneurial process. Instead, this study is of the stance that environmental conditions are the basis upon which the entrepreneurs' perception of new resource combination possibilities is formed. However, it does not mean that environmental dynamism contains more opportunities and environmental hostility contains fewer opportunities, as is usually suggested by studies adopting the discovery view of opportunity (Zahra, 1993; Edelman and Yli-Renko, 2010). The "lack" of growth opportunities in the environment is merely a reflection of the firm's lack of experience and knowledge in new fields of activity (Penrose, 1960).

Furthermore, while the literature on environmental conditions signals the importance of environment, what these studies highlight is not about environmental determinism, but about tailoring the firms' internal strategic decisions to the external environment to succeed (Miller and Friesen, 1982; Miller and Friesen, 1983; Lumpkin and Dess, 2001; Rosenbusch, Rauch and Bausch, 2013). In this regard, how the firms should adjust their entrepreneurial orientation to the environmental conditions could be an extension work in the future.

Secondly, this study uses the average resource consumption and average exploitation time of all opportunities, instead of specifying these figures for each individual opportunity. This is an inherent characteristic of the SD method—the SD method focuses on the overall while ignoring the traits of each individual entity. This aggregation characteristic of SD method has to do with the principle of conservation of flows upon which the SD method is built. It has not, however, hindered entrepreneurship and innovation scholars from applying this method. The SD method has been applied to study new product development processes, innovation implementation, technological innovation system, and so on (Repenning, 2000; Black and Repenning, 2001; Repenning, 2001, 2002; Walrave and Raven, 2016).

Thirdly, in this model firm resource stock is fuelled only by revenue from firm innovations and drained only by exploration and exploitation activities. For reason of parsimony, this study does not consider other types of resource inflow to or outflow from the overall resource stock. Because this study takes an exclusive focus on growth out of internal development, rather than growth caused by other means, such as merger & acquisition. Practically, firms could attract funding from outside sources like VC or IPO to fund growth. But we do see there are some small and new firms that lack legitimacy to attract external resources manage to grow through internally generated funds (Penrose, 1960). It might be more sensible to explore the effect of external funding acquisition after getting a thorough understanding of the internal resource accumulation mechanism.

Fourthly, for the sake of simplicity, this model adopts a static resource allocation policy into exploration and exploitation activities. Although there are some dynamic resource allocation algorithms in existence, whether they are realistic for managers to follow is an issue. Using dynamic resource allocation algorithms would also introduce the discussion of whether firms are alert enough to discover the changes immediately and whether they could swiftly make the resource allocation adjustments (Rahmandad, Repenning and Sterman, 2009). Assuming firms could immediately discover and make changes are no less unrealistic than assuming firms are following a simple static resource allocation strategy. Furthermore, this simple static resource allocation policy should be acceptable given that the analysis of the three dimensions of EO on firm growth is already complicated.

In the modelling process, I try to develop the simplest model that could capture the key structure of the firm growth process. It may be argued that multiple features could be added to the model, but the consideration is that too many details outside the scope of this study could obscure the core processes at work.

4.4. Penrose Theory in the Model

Some main contributions of Penrose theory, as acknowledged by existing studies, include the conceptualization of firm as an evolving collection of resources (Wernerfelt, 1984; Rugman and Verbeke, 2002); the distinction between resources and productive services and the key role of the productive opportunity set of the firm in firm growth (Lockett et al., 2011; Gruber, MacMillan and Thompson, 2012); the dynamic managerial limit (Pettus, 2001; Geroski, 2005); and less frequently mentioned, the dynamic approach it adopts. The following lists how each of these Penrose insights works out in the model of this study.

Firstly, consistent with Penrose study, this study models firm as a stock of resources and considers firm growth as the expansion in the firm's resource stock.

Secondly, Penrose stresses that "a theory of the growth of firms is essentially an examination of the changing productive opportunity set of the firm; in order to find a limit to growth, or a restriction on the rate of growth, the productive opportunity of a firm must be shown to be limited in any period" (Penrose, 1959, pp. 31-32). Indeed, in the current model, the productive opportunity set is the key element of the motor behind firm growth, although the other parts of the motor are also indispensable. Firm growth and decline are intimately associated with the dynamics of the productive opportunity set in the current model.

Thirdly, in Penrose theory, firm growth is not only driven by firm resources, but also is constrained by firm resources. In the model of this study, resource is the prerequisite for the entrepreneurial process to begin and for the firm growth to happen. Informed by the Penrose theory, in the current model the availability of firm resource also limits the rate of firm expansion through the variable "effect of resource availability on innovation delay" and through the resource allocation process into exploiting market demands for the firms' products. The "effect of resource availability on innovation delay" variable works in the way that the less the resource available, the longer the innovation delay, thus the slower the entrepreneurial process and the firm growth process proceed. In the model, the availability of resource also affects firm growth rate through reducing firms' ability to exploit the market demand created by the firm's innovations.

Of the different kinds of firm resources, Penrose stresses the availability of the managerial resources as the most effective limitation to the amount of expansion the firm could plan and undertake at any time. The model of this study does not distinguish the managerial resource out of the overall firm resources stock. This operationalization is on one hand for the sake of keeping the model simple; on the other hand, the development of the resource-based theory in the recent decades has shown that other kinds of firm resources, like financial resource, knowledge, technological resources, all play critical role in influencing firm growth (Wiklund and Shepherd, 2003; Mishina, Pollock and Porac, 2004; Anderson and Eshima, 2013; Kiss, Fernhaber and McDougall-Covin, 2017; Weiss, Hoegl and Gibbert, 2017). Financial capital has been shown to be fatal for firms, especially for firms in the early stage of growth. For simplicity purpose, this study aggregates all kinds of firm resource into one stock of "firm resource" in monetary terms.

Fourthly, a key feature of the limit to firm growth in Penrose theory is that the limit to firm growth by firm resource is not static or fixed but is dynamically receding. During the process of expansion, new resources are created which can be invested into expansion in the next stage. This feedback firm growth process resonates with the reinforcing firm growth loop identified in other firm growth studies (Ijiri and Simon, 1964; Bottazzi and Secchi, 2003). This reinforcing firm growth process is reflected in the model through the overall feedback loop from firm resource stock to the productive opportunity set, to the innovations stock, to firm sales, then finally back to the firm resource stock.

Another key feature of Penrose theory is the dynamic approach she adopts, as opposed to the "static" approach which imposes an optimal size where firms must stop growing. The static approach may be possible if the productive opportunity set of the firm is fixed—the maximum firm size will be reached when the firm depletes its productive opportunity set. However, Penrose excludes this possibility by finding that firm expansion is also a process of learning, during which firm's knowledge on its resources and knowledge on how to recombine its resources for new productive services increase. New productive opportunities which cannot be identified before the expansion is conducted will be identified. Under this condition, the productive opportunity set of the firm will not be fixed even when the external environment remains unchanged. This process is modelled by the link from the productive opportunity set to the opportunity identification rate–the process of exploiting entrepreneurial opportunities lead to the identification of new entrepreneurial opportunities.

Lastly, this model also contains the process through which new market demand for the firm is created. In the model, each exploited entrepreneurial opportunity will generate some certain units of sales for the firm, as denoted by the "potential sales per innovation" variable. That market demand is not as given or varies only according to price but could be created by the firm is a key point where the Penrose theory departs from the neoclassical economic theory.

4.5. Firm Growth in the Model

Firm growth in this study is represented as the change in the firm's resource stock. This operationalization is consistent with the Penrose theory of firm growth and existing studies adopting the resource-based approach to firm growth study. "Ideally, the size of a firm for our purposes should be measured with respect to the present value of the total of its resources (including its personnel) used for its own productive purposes. This is almost impossible to discover in practice, and in the absence of any satisfactory measure of size we have a wide choice depending on our purpose. For the most part, though not always, the analysis of the growth of firms that is developed in the following chapters is most directly applicable to their growth measured in terms of fixed assets." (Penrose, 1959, p. 25).

While Penrose considers the size of a firm as the present value of the total of its resource stock, she acknowledges the challenge of measuring the resource stock of a firm. Indeed, many studies take the resource-based approach to firm growth conceptualize firm growth as the change in firm's resource stock, but the empirical challenge of measuring the firm's resource stock forces these studies towards commonly used firm growth indicators such as employment growth, sales growth, etc. For example, Eshima and Anderson (2017) adopt the Penrose view of firm as collection of resources, but use the variance between revenue and asset as growth indicator to reflect the change in the firm's resource base. Lockett et al. (2011) also take firm growth as growth in firm resources– "Consistent with Penrose our theoretical and empirical focus is on the growth of firm resources." However, the empirical challenge of measuring the firm's stock of resources has made Lockett et al. (2011) use employment growth as a representation of growth in the firm's resource stock.

The abstraction inherent in simulation approach may remove the challenge in empirically measuring a firm's resource stock. As mentioned earlier, conceptually firm resource in this study refers to the stock of tangible and intangible resources the firm has (Lieberman and Montgomery, 1998). This study assumes that all kinds of resources could be turned into financial terms and go back to or come out of the firm's overall resource stock. This operationalization is mainly for the purpose of simplicity. Financial resource as liquid resource is a kind of main firm resource which allows firms high degree of discretion to convert into other uses when new opportunities emerge (Mishina, Pollock and Porac, 2004).

This operationalization finds support in the simulation literature. In simulating how the exploration of new technology is conducive to firm growth when network externality is present, Lee, Lee and Lee (2003) use the time path of firm capital, the state of which is the historical accumulation of revenue less costs over time, to represent firm growth. Coad et al. (2013) use the Gambler's Ruin framework to model firm growth through the accumulation of resources and assume that firm resource is mainly about financial resources. In studying the dynamics of capability erosion using system dynamics simulation method, Rahmandad and Repenning (2016) model firm's resource allocation decision with only one overall resource source, which is expressed in numbers.

It is possible to divide the firm resource stock into different kinds of resource stocks in this model. But the complexity and confusion caused might well outweigh the benefits it brings. Moreover, the entrepreneurial process involves the input and output of many kinds of resources. If we insist on resources being heterogenous and un-mixable, we may end up with a lengthy list of firm resource stocks and an overwhelmingly large model that eventually blurs our core purpose.

Chapter 5. Simulation Results

5.1. The Independent Role of Three EO Dimensions on Firm Growth

EO has been regarded as a matter of degree rather than a matter of yes or no (Brown, Davidsson and Wiklund, 2001). In the simulation literature, it is inevitable and it is an accepted practice to represent theoretical constructs using numerical values (Walrave and Raven, 2016). This study assumes that the degrees of firms' three dimensions of EO lie in a continuum ranging from 0 to 1, where 0 represents the firm is not innovative (or proactive or risk-taking) at all and 1 represents the firm is extremely innovative (or proactive or risk-taking). The model parameter values are informed by empirical datasets as well as existing studies. Please refer to the appendixes for detailed information. The model is simulated by Vensim software, the professional 7.2 version.

The model is initialized when the productive opportunity set and the innovations stock are in equilibrium condition. In the equilibrium condition, all stocks of the system remain unchanged; therefore conducting experimental test in this situation could get rid of the confounding effect of initial model behaviour from disequilibrium condition. As not all models have equilibrium condition, one of the alternatives is to initialize the model when some of the stocks are in equilibrium (Sterman, 2000). This "partial equilibriums scenario" is taken as a base case scenario against which the other model tests are compared. Figure 5.1-5.3 show firm growth in this base case scenario.

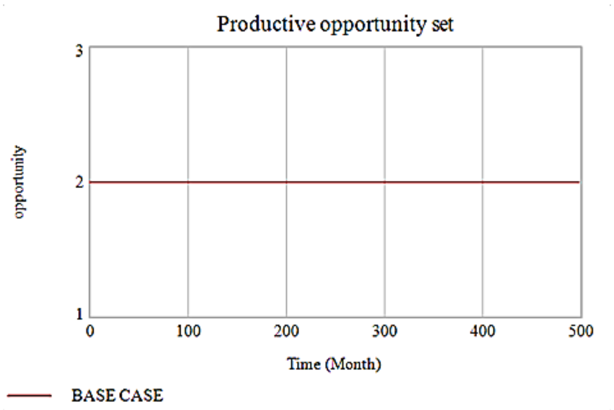


Figure 5.1 Productive opportunity set when the system is in partial equilibrium condition

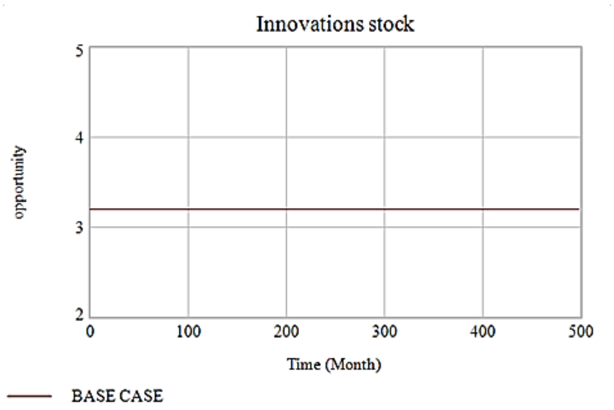


Figure 5.2 Innovations stock when the system is in partial equilibrium condition

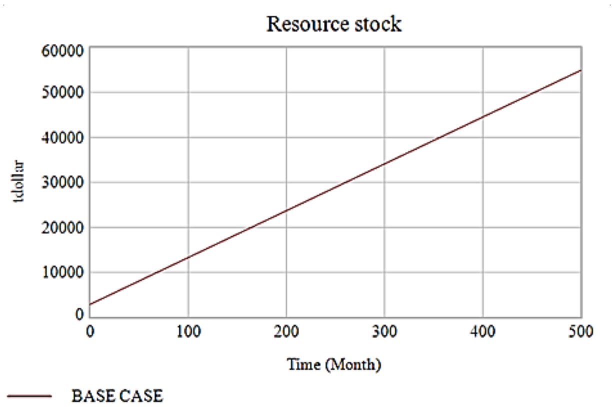


Figure 5.3 Firm growth when the system is in partial equilibrium condition

This base case scenario depicts a firm that grows in a linear way, as is usually assumed in empirical studies using linear regression model. It behaves innovatively and proactively that are just enough to replenish its productive opportunity set and innovations stock, so as not to be squeezed out of the market place. This firm is extremely risk-averse—it only pursues those opportunities that do not induce significant resource commitments and will bring back financial returns that are small but certain. Although there are some firms that possibly might grow in this way, it should be obvious that many firms grow in other different ways. To explore the other range of behaviours that could be produced by the system, I experiment with some different changes in the firm's degrees of innovativeness and proactiveness in a step way. Changing the main model variables in a step or pulse way, then comparing the changes in model behaviour against the base case scenario is the commonly used practice in System Dynamics modelling approach to understand how the focal element will influence system behaviour. A step function usually starts with a constant value, then at the designed time it steps up or down to another designated value.

5.1.1. To Test the Effect of Innovativeness on Firm Growth

To test the role of innovativeness and proactiveness, it is continually assumed that there is no risk involved in the entrepreneurial process, i.e. the payoff from entrepreneurial process is deterministic.

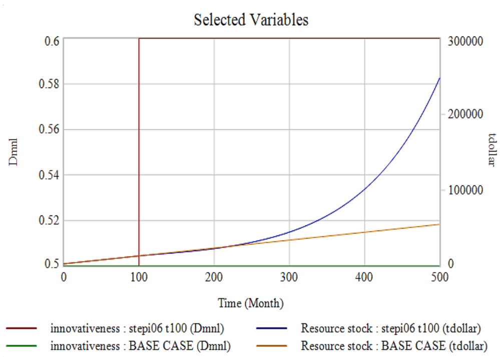


Figure 5.4 Firm growth when innovativeness is changed from 0.5 to 0.6 at month 100

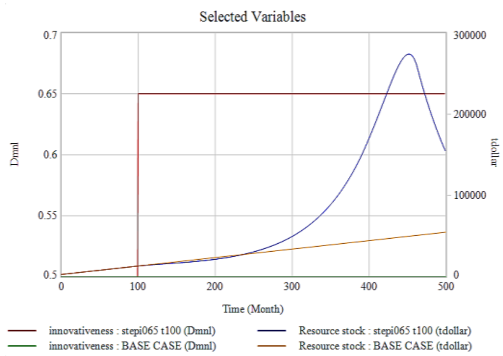


Figure 5.5 Firm growth when innovativeness is changed from 0.5 to 0.65 at month 100

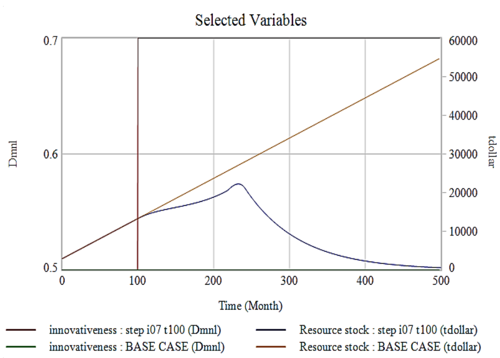


Figure 5.6 Firm growth when innovativeness is changed from 0.5 to 0.7 at month 100

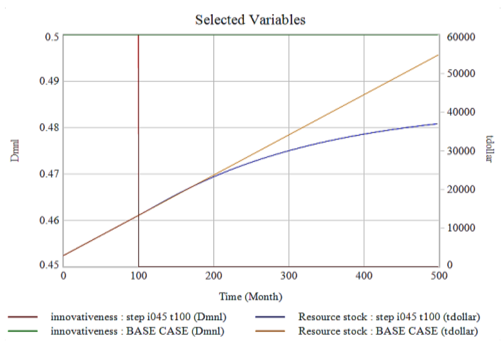


Figure 5.7 Firm growth when innovativeness is changed from 0.5 to 0.45 at month 100

Figure 5.4 shows an example of a firm switching from a degree of innovativeness of 0.5 to a slightly higher degree of 0.6 at month 100. The firm's growth rate slightly declines after this change in strategic orientation because the increased resource consumption in entrepreneurial activities and the existence of a time-delay in the resource payoff from entrepreneurial activities. Nevertheless, due to the increase in the productive opportunity set, the firm's innovation rate and innovations stock increase accordingly, leading to rising firm revenue. As the firm's resource base grows, in the next stage the firm has more resource available to invest into entrepreneurial activities. The reinforcing opportunity identification and the reinforcing firm growth loop work together as virtuous cycles causing growth rate to increase over time. Eventually, the firm's resource stock overtakes what it would be if the firm did not initiate the change in its degree of innovativeness.

As we can see, after the increase in the degree of innovativeness, it takes the firm a long time to outperform the firm which does not initiate the increase in the degree of innovativeness. This may raise the doubt of whether it is still worthwhile to engage with entrepreneurship given the existence of this long delay. If we consider the scale of growth the firm could achieve in the long run, it is not difficult to come to the conclusion that firms should still engage with entrepreneurship. One feature of exponential growth is that the change is usually not obvious in the short term, but it tends to rise dramatically in the long term.

The power of exponential growth in the long term could be best illustrated with the example of paper folding. Given a sheet of thin paper, it is hard to imagine that folding it in half will achieve anything of impact. Indeed, if we fold the paper in half ten times, we could only get a thickness of around 10cm. However, if we continue to fold this paper in half 42 times, the thickness of the paper is enough to reach the moon. Suppose the sheet of paper has an original thickness of 0.1mm, then its thickness after folding in half 42 times would be: 0.1mm*2^42= 4.3980465e+11mm, that is 439804km, while the distance between earth and moon is 384400km. If we fold it in half 103 times, the thickness of the paper will be larger than the observable universe: 93 billion light years.

Secondly, when interpreting the simulation results, we should also bear in mind that this model does not consider the possibility of firms acquiring external funds to support their entrepreneurial initiatives. Therefore, it may take longer for the firms that make significant resource commitment into entrepreneurial process to outperform those that do not.

Similar to the experiment in Figure 5.4, when the degree of firm's innovativeness is increased from 0.5 to 0.65, at month 100, the firm firstly experiences declining growth due to the resource investment into entrepreneurial opportunities, before the growth accelerates and overtakes the base case scenario. However, after growing exponentially for quite a while, the firm growth finally crashes. This is because the bigger increase in the strength of the reinforcing opportunity identification loop leads to a growing productive opportunity set and more resource consumptions by entrepreneurial activities than in the Figure 5.4 case. Having benefited consistently from the entrepreneurial process, the firm continues to invest more and more resources into pursing new opportunities. However, there is a long delay before these new projects could payoff. The firm revenue starts to fall behind the resource consumption, and thus the resource stock declines.

Figure 5.6 shows an example of a firm changing its degree of innovativeness from the original level of 0.5 to a new level of 0.7 at month 100. Like the firms in Figure 5.4 and 5.5, after this increase in entrepreneurial committements, the firm growth declines initially, but it still grows. However, after growing slowly for years, the firm growth does not continue to accelerate as the two prior cases did. Rather, the firm growth heads to a straight decline afterwards. This is because the firm faces increasing resource pressure as it continues to invest heavily into pursuing new opportunities. The firm finally reaches a point where it does not have sufficient resources to exploit the demand created by the innovations it developed. Although the firm's innovations create good market demand for the firm, it has damaged capability to capture the demands and its revenue declines further.

As firm revenue declines, its ability to conduct exploitation diminishes further. The original virtuous self-reinforcing firm growth loop turns into a vicious cycle driving firm towards decline. As the resource stock drops further, the firm reaches a point where it does not have sufficient resources for exploration activities either. The innovation delay then increases, reducing both the opportunity identification rate and the innovation rate. The balancing opportunity identification loop dominates over the reinforcing opportunity identification loop, causing the productive opportunity set to decay. Driven by the vicious circle of firm growth, the firm eventually collapses. I name this situation as 'exploration drives out exploitation, then exploitation drives out exploration'.

Figure 5.7 shows the firm growth trajectory when the firm adjusts its degree of innovativeness to a lower level of 0.45 at month 100. As the figure shows, the firm's growth rate accelerates a little bit in the beginning after the change is made. However, as time goes by, the firm growth gradually falls down and eventually stagnates. This "better before worse" scenario is caused by the fact that the reduced commitment to entrepreneurial activities results in a decline in the productive opportunity set, and thus falling resource consumption for entrepreneurial activities. As the innovation stock is not immediately affected by the decline in entrepreneurial activities, firm revenue is not influenced much in the short term. The reduced resource consumption in exploration and the temporarily unaffected firm revenue result in the increasing firm growth rate in the short term. However, as the firm's productive opportunity set decays over time—because the firm cannot identify enough opportunities to replenish its productive opportunity set, the innovation rate and the innovations stock also decay over time.

An important growth dynamics shown from the above experiments is that the relationship between entrepreneurial orientation and firm growth cannot be understood in the traditional linear proportional logic, where one unit change in innovativeness could lead to some proportional units of change in firm growth. Despite the relative similarity in these experiments, they generate qualitatively different growth trajectories: the system with 20% increase in innovativeness has exponential growth, the system with 30% increase in innovativeness suffers eventual collapse, while the system with merely 10% decrease in the degree of innovativeness results in growth stagnation. As confirmed by a more comprehensive set of simulations, a marginal difference in the degree of innovativeness could mean the difference between growth, stagnation, and collapse in the long term. Thus, the above experiments suggest that the relationship between the innovativeness dimension of EO and firm growth, rather than being linear, is better captured by the notions of tipping points and critical thresholds, which, once crossed, will cause big changes in the firm's growth trajectory.

5.1.2. To Test the Effect of Proactiveness on Firm Growth

Following the same logic, I conducted a similar set of experiments to understand the effect of the proactiveness dimension of EO on firm growth. Figure 5.8-5.11 show simulation results of a few of the experiments.

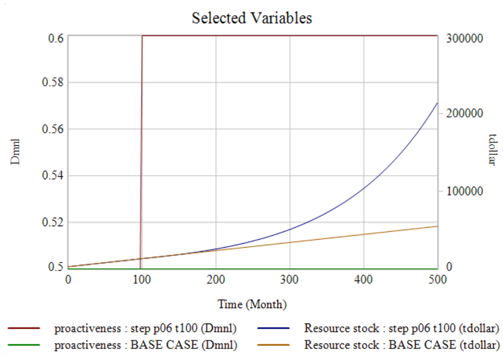


Figure 5.8 Firm growth dynamics when proactiveness is changed from 0.5 to 0.6 at month 100

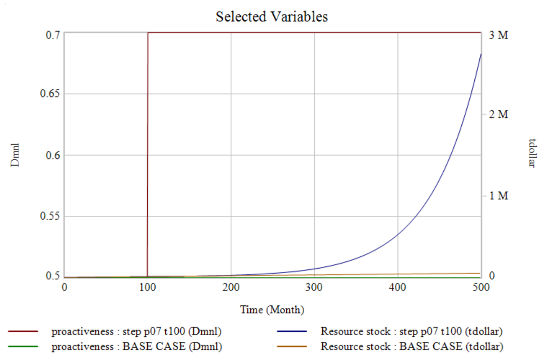


Figure 5.9 Firm growth dynamics when proactiveness is changed from 0.5 to 0.7 at month 100

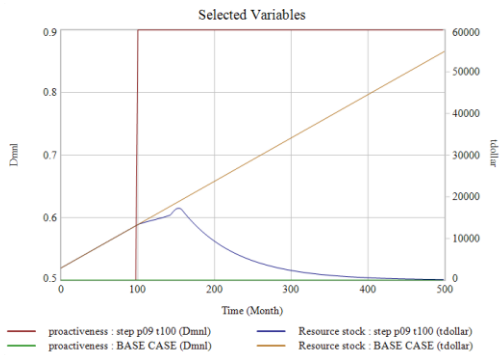


Figure 5.10 Firm growth dynamics when proactiveness is changed from 0.5 to 0.9 at month 100

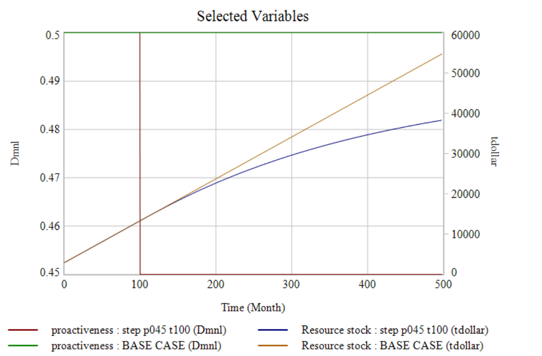


Figure 5.11 Firm growth dynamics when proactiveness is changed from 0.5 to 0.45 at month 100

Figure 5.8 shows an experiment in which the degree of a firm's proactiveness is increased from a level of 0.5 to 0.6 at month 100. Interestingly, long time after this change in proactiveness is made there is no notable change in the firm's growth. Until around month 170, firm growth starts to surpass its original growth course, and firm growth accelerates gradually since then. The firm experiences high growth in the long run.

Figure 5.9 shows the growth course of a firm when it adjusts its degree of proactiveness from the original degree of 0.5 to 0.7 at month 100. Again, there is no obvious change in firm growth for long after this change in firm's proactivity was made. However, at around month 200, firm growth starts to pick up and surpass the firm's original growth course. Firm growth accelerates gradually, at a rate bigger than the case when the degree of proactiveness is increased to 0.6.

Figure 5.10 shows an experiment of a firm adjusting its degree of proactiveness to a level of 0.9 from its original level of 0.5. Compared with Figure 5.8 and Figure 5.9, the firm growth trajectory starts to show divergence from the original growth course more quickly after this change in firm's proactiveness was made. However, in contrast to experiments in Figure 5.8 and Figure 5.9, firm growth falls behind the original growth course, before it collapses. This growth pattern bears some resemblance to the growth in Figure 5.6.

In Figure 5.11, the firm alters its degree of proactiveness from the original level of 0.5 to a lower level of 0.45. Like the previous cases, there is no obvious change in firm growth for long after this change was made. However, the figure shows that as time goes by, firm growth keeps decelerating with no sign of surpassing the original growth course.

As confirmed by other more extensive simulation runs, the results show that when proactiveness is at low levels, the growth eventually stagnates; when proactiveness is at moderate and slightly higher levels, the firm grows exponentially; when proactiveness is at very high levels, however, the firm growth declines. Notably, there are some similarities between the effect of innovativeness on firm growth and the effect of proactiveness on firm growth. Firstly, both dimensions produce three different patterns of firm growth: stagnation, exponential growth, and collapse. Secondly, when proactiveness or innovativeness are at low levels, the resulted firm growth pattern is eventual stagnation. When proactiveness or innovativeness are at very high levels, firm growth eventually collapses. Thirdly, whether it is changing innovativeness or proactiveness, there all exists a time delay for the effect to take place. Fourthly, the effects of innovativeness and proactiveness on firm growth all exhibit the tipping point behaviour. This similarity between the effect of proactiveness and the effect of innovativeness is partly down to the fact that proactiveness, like innovativeness, also affects the opportunity identification rate, albeit indirectly through influencing the innovation delay.

Despite the similarities, proactiveness has a wider range where it produces exponential pattern of growth—up to proactiveness is 0.7, the growth pattern is still exponential growth, while in the innovativeness case, innovativeness at 0.65 turns the growth into collapse. This is because proactiveness not only increases the opportunity identification rate but also shortens the duration of the entrepreneurial opportunity identification and exploitation, thus reducing the resource commitment involved.

5.1.3. To Test the Effect of Risk-taking on Firm Growth

As with risk comes randomness, the effect of risk-taking on firm growth could only be known in a probabilistic way. To understand the effect of risk-taking on the firm growth process, I conducted extensive Monte Carlo simulation analysis. I conducted 1000 simulation runs for each of eleven different risk-taking levels ranging from 0 to 1, at an interval of 0.1. To overcome the problem of survival bias, I chose both variables related to firm growth and to firm failure in summarizing the wealth of data. I calculated and plotted the probability of firm failure, i.e. the fraction of simulation runs that the resource stock is exhausted at the end of the simulation and the upper 95% resource stock level, i.e. the 95% resource stock level arrived among the 1000 simulation runs at the end of the simulation.

Figure 5.12 plots the likelihood of firm failure and the 95% resource stock level arrived among the 1000 simulation runs at the end of the simulation at different degrees of risk-taking. As can be seen from Figure 5.12, as the degree of risk-taking increases, the probability of failure the firm faces increases correspondingly. Nevertheless, the analysis reveals that the 95% firm resource stock level arrived among the 1000 runs at the end of the simulation also increases with risk-taking increasing. This indicates that high risk-taking also provides firms the potential to grow into extra-large businesses. This result is consistent with the common conceptualization of risk-taking that high risk-taking is usually associated with high return. To confirm that this result is not a particular result out of any particular snapshot during the simulation, Figure 5.13 plots the likelihood of firm failure and the 95% resource stock level arrived among the 1000 runs in the halfway of the simulation. Figure 5.13 shows similar curves to Figure 5.12.

Another insight gained through the two figures is that neither the probability of firm failure nor the 95% level of resource stock increases linearly as the level of risk-taking increases. Firm growth potential, i.e. the 95% resource stock level out of the simulation runs, seems to increase at a decreasing rate as the degree of risk increases. The probability of failure, increases very slowly when risk-taking is at low levels, while starting to increase quickly when risk-taking approaches medium level. This seems to indicate the existence of “cutoff” level of risk-taking, at which point the probability of firm failure starts to take off.

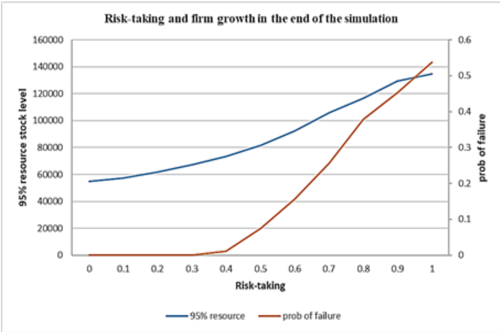


Figure 5.12 Risk-taking and firm growth in the end of the simulation

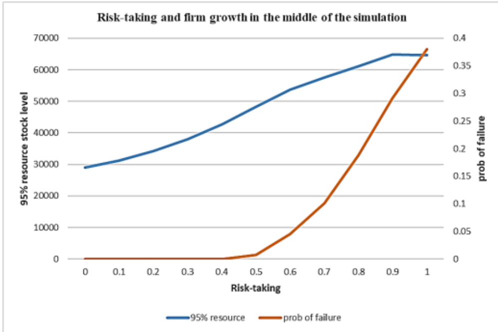


Figure 5.13 Risk-taking and firm growth in the middle of the simulation

5.2. The Interplay of Innovativeness and Proactiveness on Firm Growth

The above simulations suggest that small differences in the level of innovativeness or proactiveness could mean fundamentally different modes of firm growth. This finding raises the question of how much proactiveness or innovativeness is required for firms to escape from the growth stagnation, but also just enough to avoid the collapse? Given that in the above tests, the effect of innovativeness was examined when proactiveness was held constant, and vice versa. A question then arises as to how innovativeness and proactiveness will interact with each other to produce different growth modes. To shed light on this question, I performed a further set of experiments to understand the interplay of proactiveness and innovativeness and firm growth trajectories. Specifically, for each level of innovativeness, I conducted a series of experiments to identify the thresholds of proactiveness that separate the different modes of growth. In these set of simulations, all model parameters were the same as in the base case, except the values of innovativeness and proactiveness. These experiments were still carried under the assumption that there was no risk in the entrepreneurial process. Data coming out of these simulations were transformed into the following figures:

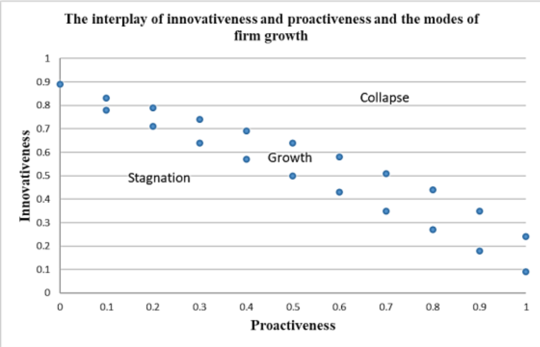


Figure 5.14 The interplay of innovativeness and proactiveness and the modes of firm growth

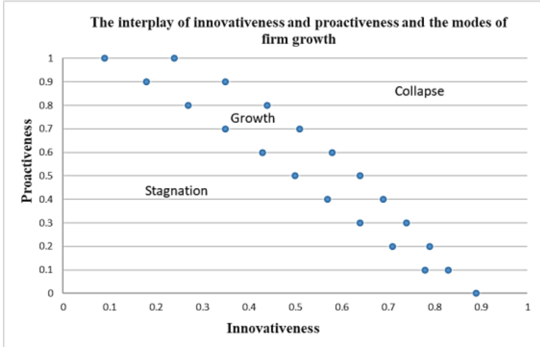


Figure 5.15 The interplay of innovativeness and proactiveness and the modes of firm growth

These simulations, with different combinations of innovativeness and proactiveness, separate into three distinct growth patterns. In Figure 5.14, the area corresponding to low innovativeness represents growth trajectories characterized by eventual growth stagnation, while the area inclined to high innovativeness represents growth trajectories characterized by collapse. The relatively small area between the dots represents the combinations of the levels of proactiveness and innovativeness that produce exponential firm growth. The first insight gained into the figure is that the area in which innovativeness and proactiveness interact to produce exponential firm growth is much smaller than the areas in which innovativeness and proactiveness jointly result in growth stagnation or collapse.

Simulation results in the last section show that under partial equilibrium condition, when innovativeness is at very low levels, growth is characterized by eventual stagnation. When innovativeness is at very high levels, firm growth is going to collapse ultimately. This result largely holds true when taking the firm's degree of proactiveness into account. Figure 5.14 shows that when the firm is unwilling to engage with or to support new resource recombination ideas, firm growth will stagnate regardless of how proactive the firm is. When the firm is highly innovative, firm growth will eventually collapse no matter how proactive the firm is. This indicates that when the firm goes to extremes in terms of being innovative, i.e. being highly innovative or being not innovative at all, proactiveness plays no role in changing the destiny of stagnation or collapse caused by innovativeness.

Nonetheless, Figure 5.14 shows that the thresholds of innovativeness that separate the different growth modes vary, depending on how proactive the firm is. Looking from left to right in Figure 5.14, as the firm's level of proactiveness increases, the thresholds of innovativeness to escape stagnation and to avoid collapse get smaller. What this result reveals is that the exact thresholds of innovativeness distinguishing the different growth modes are dependent on how proactive the firm is.

This interaction effect between innovativeness and proactiveness is down to the fact that both innovativeness and proactiveness play a role in the dynamics of the productive opportunity set of the firm. Innovativeness increases the rate at which the firm identifies new productive opportunities, while proactiveness increases the rate at which the firm acts upon the identified productive opportunities. Both of them positively affect the strength of the opportunity exploitation loop, leading to an increasingly growing productive opportunity set. A highly proactive firm, which quickly acts upon potential opportunities, requires a lower level of commitment to innovative activities to get rid of the growth stagnation and requires a reduction in innovation efforts to get away from collapse than firms that are less proactive. Another observation made from Figure 5.14 is that the range of values in innovativeness that produces growth tends to slightly enlarge as the level of proactiveness increases. This suggests that while the levels of innovativeness producing high growth fall as proactiveness escalates, there tends to be a wider range of innovativeness levels that could produces high growth as proactiveness rises.

To gain some further understanding of the interaction effects between innovativeness and proactiveness on firm growth, I rotated the Figure 5.14, which became the figure in the right, i.e. Figure 5.15. From Figure 5.15, we could see that similar to the case of innovativeness, when the firm lacks proactiveness to capture new opportunities, it will not be capable of growing sustainably no matter how innovative it is. When the firm's proactiveness is at very low levels, its growth will eventually either stagnate or collapse depending on how innovative the firm is. The firm needs at least some small degree of proactiveness in order to have the prospect of growing sustainably over time. However, unlike the situation in innovativeness, when the firm is characterized by high proactiveness, there still exist a range of innovativeness levels within which firms could grow exponentially.

Further from Figure 5.15, as innovativeness increases, the thresholds in the level of proactiveness that separate stagnation and growth, growth and collapse, also fall accordingly. A close examination reveals that the fall happens more quickly when compared with the case in innovativeness. This implies that the same amount of change in the level of innovativeness requires a relatively bigger adjustment in the level of proactiveness to get the desired growth mode, compared with the amount of innovativeness required to get the desired growth mode when initiating the same degree of change in proactiveness.

Contrasting Figure 5.14 with Figure 5.15 reveals some further findings on the different effects of innovativeness and proactiveness on firm growth. Firstly, in contrast to Figure 5.14, Figure 5.15 shows that the range of proactiveness levels that produces high growth, however, gets narrower as innovativeness increases. Secondly, the two figures show that the high growth pattern mainly happens when innovativeness is at moderate to low levels, while the high growth pattern mainly happens when proactiveness is at moderate to high levels.

In summary, the above simulation results suggest that the thresholds in innovativeness that separate the different modes of growth are dependent on the level of proactiveness of the firm, and vice versa. The effects of innovativeness and proactiveness on firm growth are therefore interdependent. However, while proactiveness and innovativeness could change each other’s thresholds separating different growth modes, they cannot fully eliminate the stagnation or collapse in growth caused by the other dimension. Furthermore, there are similarities as well as differences between the effect of innovativeness and the effect of proactiveness on firm growth dynamics.

5.3. The Interactions of Three EO dimensions on Firm Growth

The set of experiments in the last section shows how innovativeness and proactiveness interact with each other to give rise to the different growth modes of the firms. However, the above results still cannot give us a full picture of the role of EO on firm growth. Because, as mentioned earlier, these experiments were carried out under the assumption that there is no risk involved in the entrepreneurial process. This assumption in most cases does not hold and further investigation is needed to gain an understanding of how the system behaves under risky conditions.

The previous simulation results reveal the existence of tipping point behaviour in firm growth as caused by innovativeness and proactiveness, in the absence of risk. The question arises then is, how will risk-taking affect the tipping point behaviour caused by innovativeness and proactiveness? Is there any degree of risk-taking able to free firms from the tipping point behaviour generated by innovativeness and proactiveness? If not, will the thresholds in innovativeness and proactiveness separating different growth modes be different under different conditions of risk-taking?

Secondly, the interplay of innovativeness and proactiveness produces different growth patterns of firms. Under the circumstances that innovativeness and proactiveness jointly produce exponential growth in the absence of risk-taking, how will risk-taking change the exponential growth outcome? In the same vein, under the circumstances that innovativeness and proactiveness jointly lead to growth stagnation or collapse, how will risk-taking change the growth outcomes? Will being risk-taking save firms from the destiny of stagnation or collapse as caused by innovativeness and proactiveness, or will being risk-taking make the situation even worse?

Thirdly, experiments in the last section show that there exists an interaction effect between the effect of innovativeness and that of proactiveness on firm growth. Will this interaction effect be different under different levels of risk-taking? And if yes, how will it change?

Lastly, if risk-taking indeed could significantly alter the system behaviour as produced by innovativeness and proactiveness, what is the underlying mechanism behind its power? How does this mechanism differ from the mechanisms of innovativeness and proactiveness on firm growth?

To answer these questions, I conducted and inspected an extensive set of simulations. The following figures show some example simulation runs in order to illustrate the findings. Each experiment has 250 simulation runs (Walrave and Raven, 2016).

5.3.1. Risk-taking and Growth Stagnation

Risk-taking and growth stagnation, some example simulation runs:

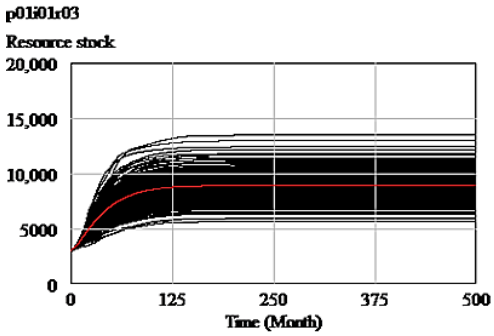


Figure 5.16 How low risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p01i01r03

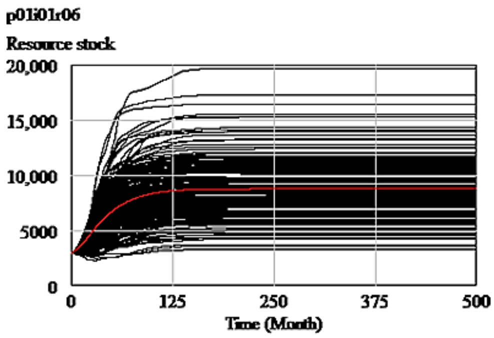


Figure 5.17 How moderate risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p01i01r06

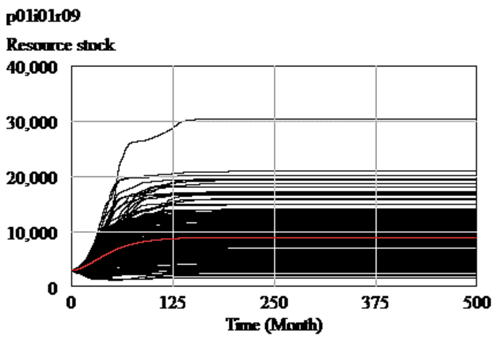


Figure 5.18 How high risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p01i01r09

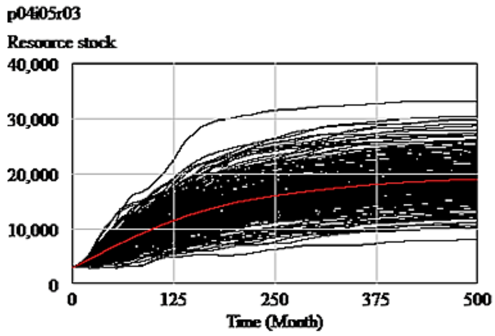


Figure 5.19 How low risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p04i05r03

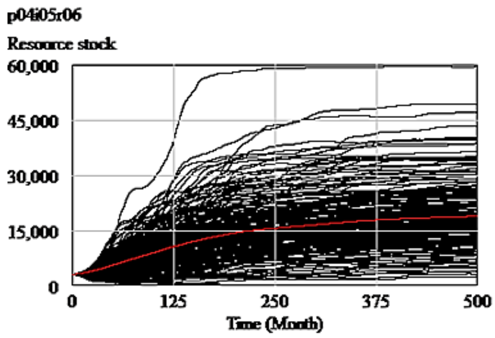


Figure 5.20 How moderate risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p04i05r06

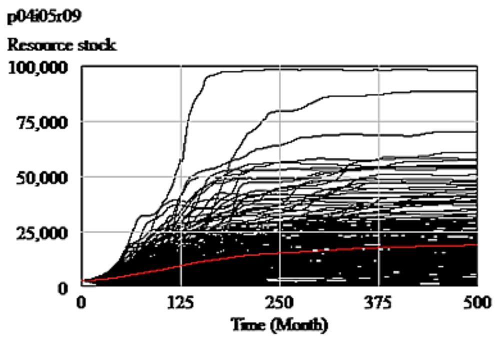


Figure 5.21 How high risk-taking changes growth stagnation−firm growth trajectories out of 250 simulations, p04i05r09

The three figures in the left column, i.e. Figure 5.16, 5.17 and 5.18, depict the simulation runs when innovativeness and proactiveness are all at the level of 0.1, while risk-taking is at the level of 0.3, 0.6, and 0.9 respectively. Under the condition when innovativeness and proactiveness are both at the level of 0.1, if the firm does not take any risk, firm growth will stagnate in the end. The three figures show that under the condition that the firm takes risk, the higher the risk the firm takes, the higher the variance in the eventual resource stock levels arrived. However, taking risk cannot turn the growth stagnation into exponential growth. This is down to the fact that risk-taking has to do with the kind of opportunities that the firm pursue, instead of the rate at which the opportunities are identified and exploited. Without being sufficiently innovative to identify opportunities or proactive to act upon the opportunities, the productive opportunity set of the firm will gradually decline, eventually resulting in growth stagnation.

The three figures in the right column, i.e. Figure 5.19, 5.20, and 5.21, represent the possible firm growth trajectories when proactiveness is 0.4 and innovativeness is 0.5, while risk-taking is at 0.3, 0.6, and 0.9 respectively. Under the condition when proactiveness is 0.4 and innovativeness is 0.5, if the firm is extremely risk aversion, firm growth will stagnate in the end. The three figures show that risk-taking could turn some growth stagnation into collapses, and the higher the risk the firm takes, the more likely it collapses. This is because the higher the risk the firm takes, the more likely the firm will encounter huge losses that trigger the change in the direction of the reinforcing growth loop and make the firm caught up in a vicious spiral of collapse.

5.3.2. Risk-taking and Exponential Firm Growth

Risk-taking and firm growth: some example simulation runs:

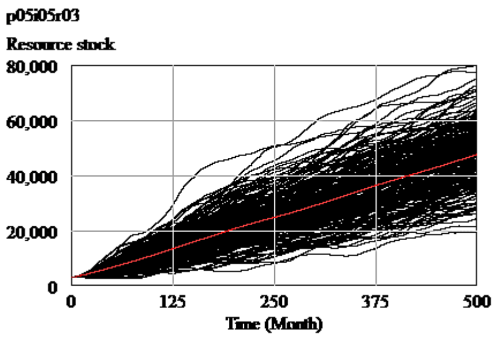


Figure 5.22 How low risk-taking changes linear growth –firm growth trajectories out of 250 simulations, p05i05r03

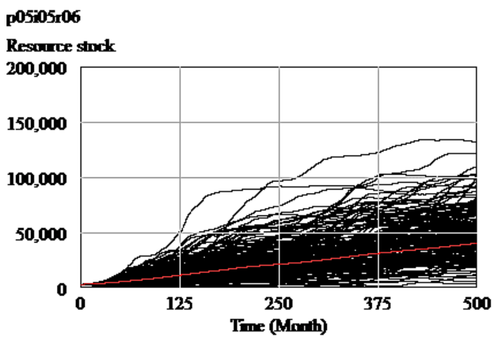


Figure 5.23 How moderate risk-taking changes linear growth –firm growth trajectories out of 250 simulations, p05i05r06

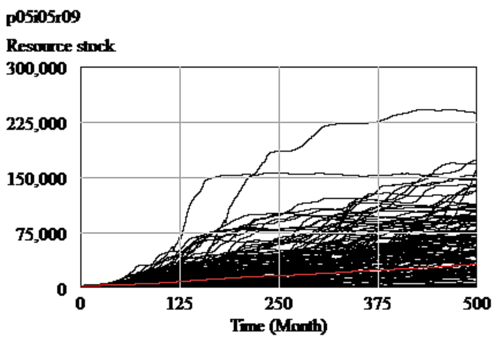


Figure 5.24 How high risk-taking changes linear growth –firm growth trajectories out of 250 simulations, p05i05r09

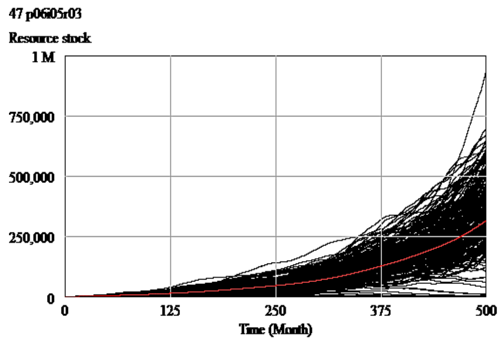


Figure 5.25 How low risk-taking changes exponential growth –firm growth trajectories out of 250 simulations, p06i05r03

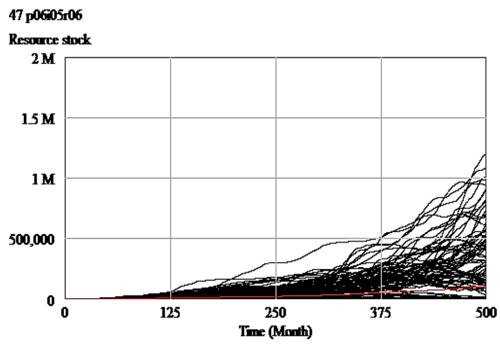


Figure 5.26 How moderate risk-taking changes exponential growth –firm growth trajectories out of 250 simulations, p06i05r06

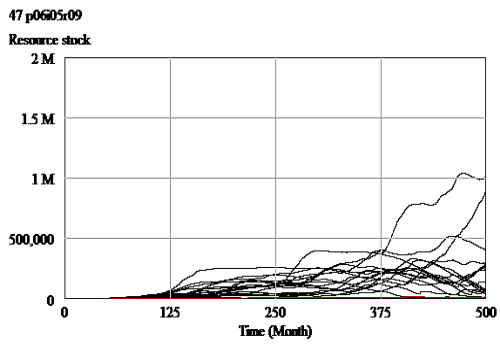


Figure 5.27 How high risk-taking changes exponential growth –firm growth trajectories out of 250 simulations, p06i05r09

The analysis shows that the effect of risk-taking on firm growth is more complicated when the firm grows sustainably overtime due to the combination of innovativeness and proactiveness. Figure 5.22, 5.23, and 5.24 show the possible firm growth trajectories under three different risk-taking conditions when the firm is moderately innovative at 0.5 and proactive at 0.5. Under this innovativeness and proactiveness combination, the firm grows linearly if there is no risk involved in the entrepreneurial process. As can be seen in the figures, risk-taking turns some of the growth patterns into collapse, and the higher the risk involved, the more likely the firm will fail. Nevertheless, high risk-taking also enables the surviving firms to grow to much bigger enterprises than they would do if they take a small risk. Figure 5.25, 5.26, and 5.27 show the possible firm growth trajectories under three different risk-taking conditions when the firm is proactive at 0.6 and innovative at 0.5. In the case when proactiveness is 0.6 and innovativeness is 0.5, if no risk is involved in the entrepreneurial process, the firm grows exponentially, at a scale larger than firm grows when innovativeness is 0.5 and proactiveness is 0.5.

Comparing the three figures in the right column with the three figures in the left column, when firms' risk-taking are at low to moderate levels, there are more firms failing and less firms growing sustainably when innovativeness is 0.6 and proactiveness is 0.5 than those when innovativeness is 0.5 and proactiveness is 0.5. Nevertheless, the 95% resource stock levels are significantly higher when innovativeness is 0.6 and proactiveness is 0.5 than when both innovativeness and proactiveness are at 0.5. When risk-taking is at a high level, however, Figures 5.27 shows that there are not many firms that could have high growth in the end, if they have a level of proactiveness at 0.6 and a level of innovativeness at 0.5. When proactiveness is 0.6 and innovativeness is 0.5, high risk-taking produces the worst resource level at the upper 95% limit, compared with low and moderate risk-taking.

This suggests that the finding in the last section that high risk-taking leads to high growth potential does not always hold true. In the case when proactiveness is at 0.6 and innovativeness at 0.5, moderate risk-taking seems to produce the highest growth potential in terms of the upper 95% resource level, rather than high risk-taking as in the case when proactiveness and innovativeness are both at 0.5. Figures 5.25, 5.26, and 5.27 show that although the 95% growth level produced by low risk-taking is not as high as that of moderate risk-taking, the chance of having sustainably high growth over time is higher than that if the firm takes moderate level of risk-taking. High risk-taking firms, in this case, perform the worst–the majority of firms fail in the end.

An examination of more simulation runs reveals that the effect of risk-taking on firm growth varies, depending on the levels of innovativeness and proactiveness. To provide more evidence for this finding, the following Figures 5.28, 5.29, and 5.30 present the scenarios when proactiveness is at an extreme high level of 1, innovativeness at a very low level of 0.1, and risk-taking at 0.3, 0.6, and 0.9 respectively. Figures 5.31, 5.32, and 5.33 present the scenarios when proactiveness is at 1, innovativeness is at 0.2, and risk-taking at 0.3, 0.6, and 0.9 respectively:

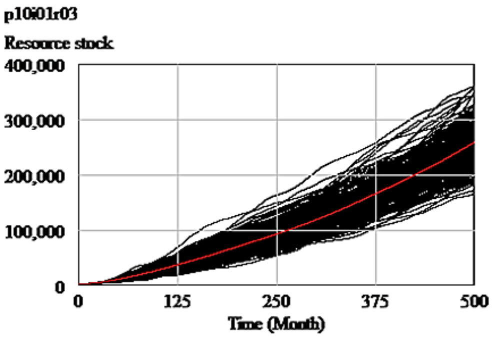


Figure 5.28 How low risk-taking changes exponential growth−firm growth trajectories out of 250 simulations, p10i01r03

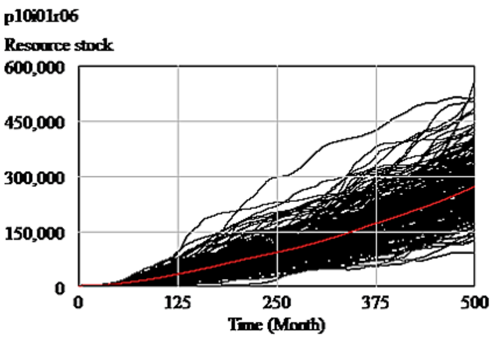


Figure 5.29 How moderate risk-taking changes exponential growth-firm growth trajectories out of 250 simulations, p10i01r03

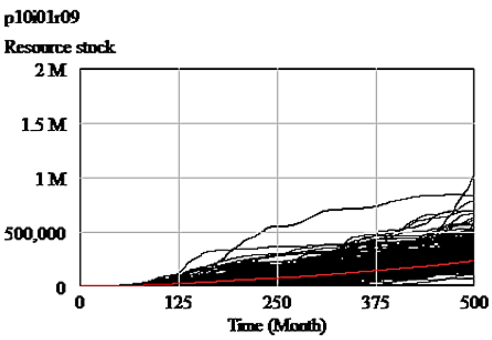


Figure 5.30 How high risk-taking changes exponential growth−firm growth trajectories out of 250 simulations, p10i01r09

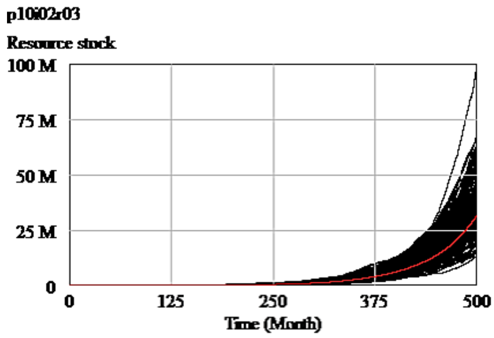


Figure 5.31 How low risk-taking changes exponential growth−firm growth trajectories out of 250 simulations, p10i02r03

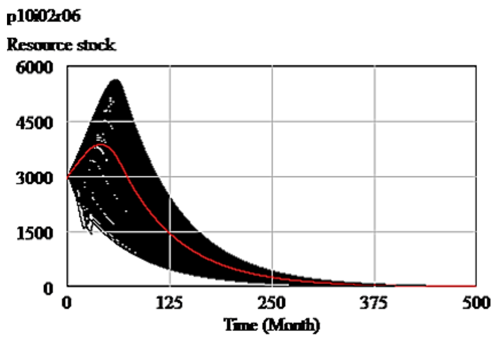


Figure 5.32 How moderate risk-taking changes exponential growth−firm growth trajectories out of 250 simulations, p10i02r06

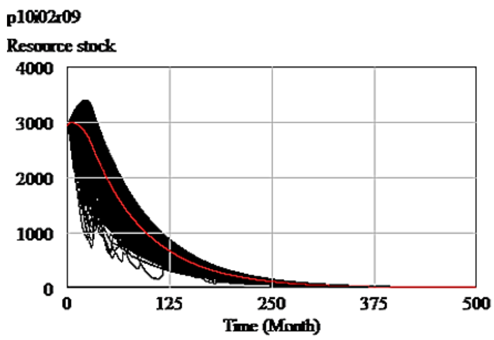


Figure 5.33 How high risk-taking changes exponential growth−firm growth trajectories out of 250 simulations, p10i02r09

Figures 5.28-5.30 show that when proactiveness is 1, innovativeness is 0.1, high risk-taking brings simultaneously high likelihood of firm failure and high firm growth potential. When proactiveness is 1 and innovativeness is 0.2, however, there is no firm growing continuously at all for moderate or high risk-taking, as is shown in Figure 5.32 and 5.33. In this case, even moderate risk-taking loses the power of improving firms' growth potential. As the combination of innovativeness and proactiveness in Figure 5.30 could still lead some firms to very high growth, an implication we could draw from the contrasts between Figure 5.29 and Figure 5.32, between Figure 5.30 and Figure 5.33 is that high risk-taking could reduce the thresholds in innovativeness and proactiveness beyond which firm collapse is a definite rather than a probabilistic thing. By this I mean, some of the combinations of innovativeness and proactiveness that produce exponential growth under the condition of low risk-taking result in a universal firm collapse in the context of high risk-taking. High risk-taking thus makes the area between the dots in Figure 5.14 smaller.

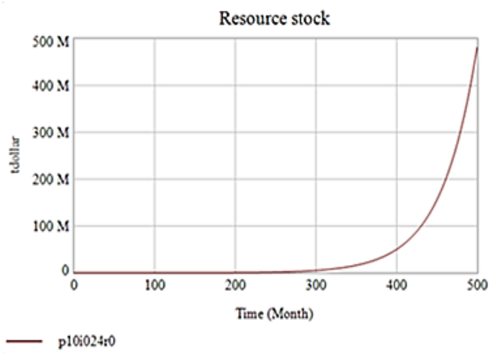


Figure 5.34 Firm growth when proactiveness is 1, innovativeness is 0.24, and risktaking is 0

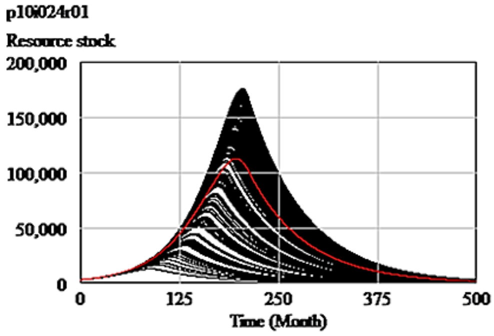


Figure 5.35 How risktaking changes exponential growth-firm growth trajectories out of 250 simulation runs, p10i024r01

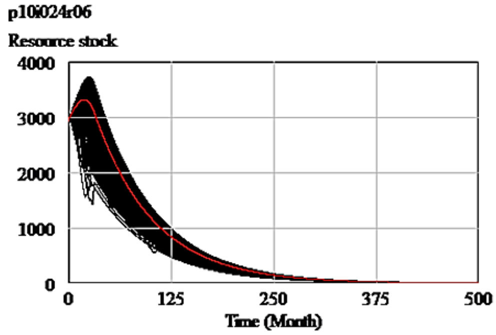


Figure 5.37 How risktaking changes exponential growth-firm growth trajectories out of 250 simulation runs, p10i024r06

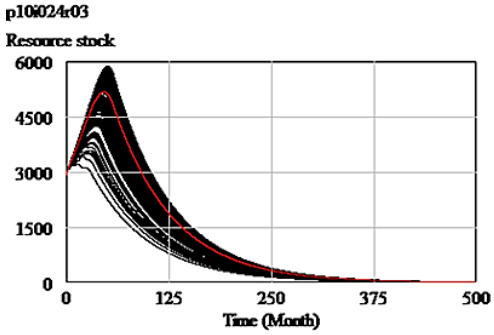


Figure 5.36 How risktaking changes exponential growth-firm growth trajectories out of 250 simulation runs, p10i024r03

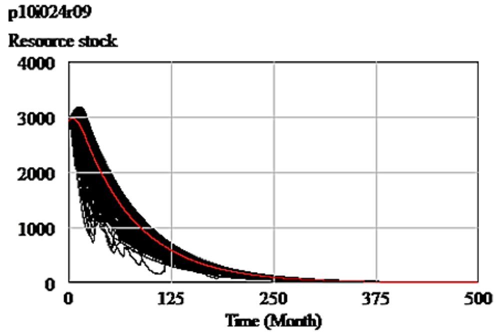


Figure 5.38 How risktaking changes exponential growth-firm growth trajectories out of 250 simulation runs, p10i024r09

Figure 5.34-5.38 show possible firm growth trajectories when proactiveness is at an extreme level of 1, innovativeness is at 0.24, and risk-taking is at different levels. Under this condition, if there is no risk involved in the entrepreneurial process, the firm has very high rate of growth over time, as is shown in Figure 5.34. However, what these figures show is that when the firm is having very high growth due to its innovativeness and proactiveness, taking even the smallest risk will be catastrophic. As can be seen in Figure 5.35, there is no growth at all for a risk-taking level as small as 0.1.

Under this condition, risk-taking is purely detrimental for firm growth—it has completely lost its power of enlarging firm's growth potential. One implication from this result is that not only small changes in innovativeness or proactiveness but also small changes in risk-taking could also cause disruptive changes to firm growth. This abrupt change in firm growth caused by risk-taking, however, does not happen on all occasions—it only happens when the firm is having very high growth because of its levels of innovativeness and proactiveness.

As mentioned above, one major finding of this part is that the higher the growth out of being innovative and proactive, the more susceptible the firm is to risks. This is because a quickly growing productive opportunity set leads to increasingly growing resource pressure for the firm. The firm thus becomes more susceptible to potential losses in the entrepreneurial process. What this means is that it will be easier for the reinforcing growth loop to switch into a vicious circle and that once this happens, it will be more difficult to pull the firm out of the vicious spiral. But at the same time, firms that are lucky to get a good payoff from the entrepreneurial process are more likely to grow more in the future.

5.3.3. Risk-taking and Firm Collapse

Risk-taking and firm collapse, some example simulation runs:

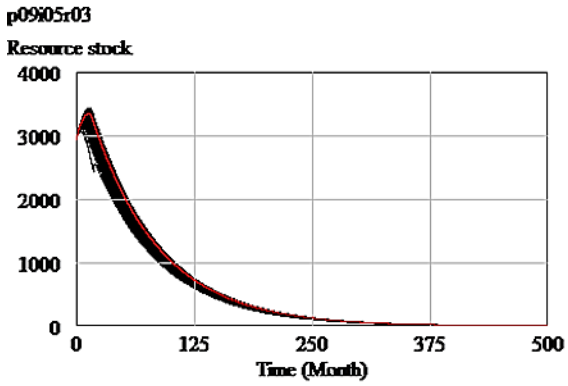


Figure 5.39 How low risk-taking changes growth collapse−firm growth trajectories out of 250 simulations, p09i05r03

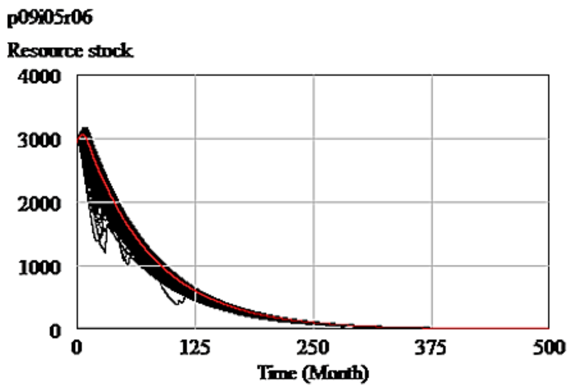


Figure 5.40 How moderate risk-taking changes growth collapse−firm growth trajectories out of 250 simulations, p09i05r06

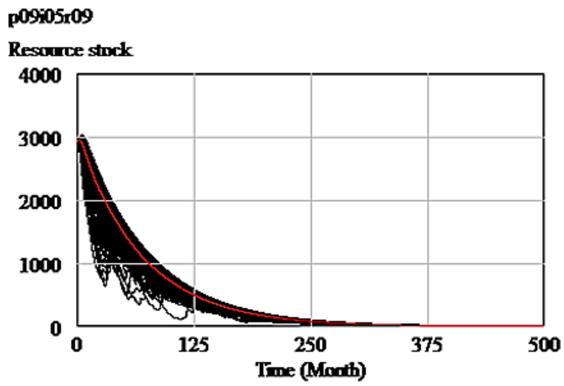


Figure 5.41 How high risk-taking changes growth collapse−firm growth trajectories out of 250 simulations, p09i05r09

Figure 5.39-5.41 show how risk-taking changes firm growth when the firm is in the collapse mode produced by innovativeness and proactiveness. The results show that risk-taking sadly cannot save firms from the destiny of collapse as a result of their innovativeness and proactiveness.

Table 5.1 Summary statistics of the final resource level in the simulation runs

	mean	sd	95% resource stock level
p01 i01 r03	8895	1332	11037
p01 i01 r06	8754	2605	13457
p01 i01 r09	8918	3959	16634
p04 i05 r03	18953	4077	26026
p04 i05 r06	18836	9166	34636
p04 i05 r09	18871	15778	47944
p05 i05 r03	47554	10595	64023
p05 i05 r06	40273	28807	91341
p05 i05 r09	31873	44737	123363
P06 i05 r03	316980	179626	602950
P06 i05 r06	105679	234779	668014
P06 i05 r09	16050	94732	57151
p10 i01 r03	258645	36985	323538
p10 i01 r06	271915	91124	427527
p10 i01 r09	234263	196277	530673
p10 i02 r03	31600000	17966492	59248115
p10 i02 r06	8	3	13
p10 i02 r09	3	0.9	4.5
p10 i024 r01	1839	1040	3045
p10 i024 r03	10	2	12
p10 i024 r06	4.5	0.8	5
p10 i024 r09	3	0.7	4
p09 i05 r03	4	0.2	4
p09 i05 r06	3	0.3	4
p09 i05 r09	2	0.5	3

Having gained a qualitative understanding of the effects of risk-taking on the different firm growth modes produced by innovativeness and proactiveness, I now proceed to investigate firm growth under more extensive combinations of the three EO dimensions and to examine if there exists a dimensional configuration of EO that is best for long-term firm growth. In this section, I conducted an enormous number of Monte Carlo simulations to explore the system behaviour for a broader and more complete set of combinations of the three EO dimensions. The levels of innovativeness and proactiveness were chosen between 0 and 1, at the interval of 0.1, while risk-taking had three representative levels: low level of 0.3, moderate level of 0.6, and high level of 0.9. For each combination of innovativeness and proactiveness at each of the three risk-taking levels, 250 simulations were performed. To summarize this wealth of data, I still choose the upper 95% resource stock level out of the 250 runs at the end of the simulation and the probability of firm failure at the end of the simulation as the outcome variables. The results are displayed in the form of 3D figures. The horizontal axis represents the level of proactiveness, while the vertical axis represents the level of innovativeness. The values of the two outcome variables were plotted into the z-axis.

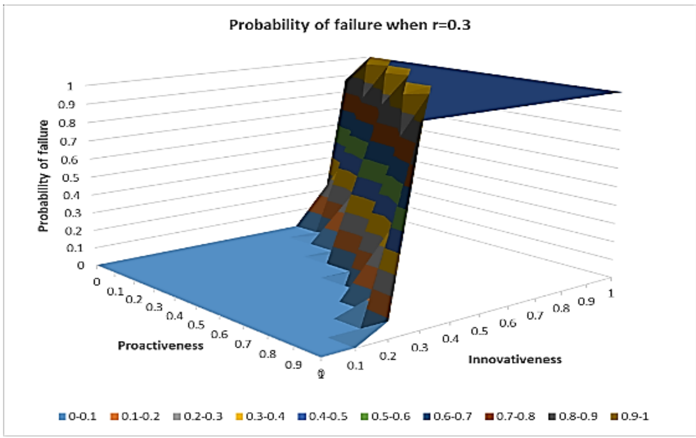


Figure 5.42 The interplay of innovativeness and proactiveness and the likelihood of firm failure when risk-taking is at a low level of 0.3

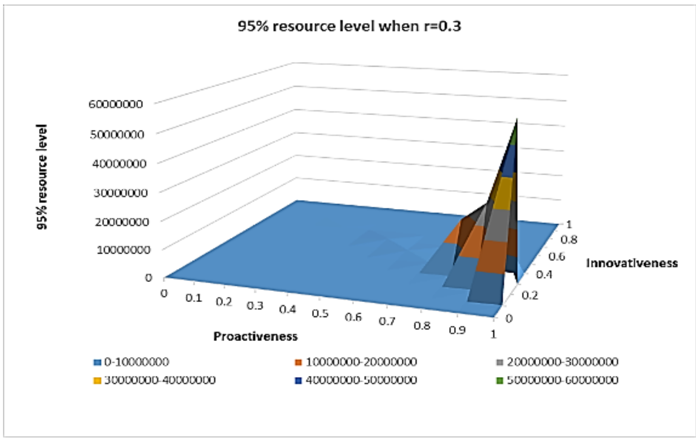


Figure 5.43 The interplay of innovativeness and proactiveness and firm growth when risk-taking is at a low level of 0.3

Figure 5.42 and Figure 5.43 show the probability of firm failure and the 95% resource stock level at different combinations of proactiveness and innovativeness values respectively when risk-taking is at the level of 0.3. Each dot in the surface represents the result out of 250 simulation runs. We could see that when innovativeness is at very low or very high levels, no matter how proactive the firm is, it is not going to have sustained growth. Because as can be seen in the figures, when innovativeness is at very low levels, the 95% resource stock level is very low; and when innovativeness is at very high levels, the probability of failure is 1. (Please note that in the case of growth stagnation the probability of firm failure is zero because the resource stock is not exhausted at the end of the simulation, but this does not mean there is growth). As can be seen in Figure 5.42, the probability of firm failure figure stretches towards the direction where proactiveness and innovativeness are high.

When proactiveness is at low levels, there is barely any growth, as shown in the plunged area in Figure 5.43. When proactiveness is at high levels, there exist some levels of innovativeness that could produce high growth. These results are consistent with the findings from Figure 5.14 and Figure 5.15. From Figure 5.42 and Figure 5.43, we could conclude that the previous findings that when innovativeness is too low or too high, firms could not have exponential growth and when proactiveness is too low, there is no high growth still hold under the condition of low risk-taking.

At a given level of proactiveness, as innovativeness increases, both the probability of firm failure and the 95% firm resourve level increase correspondingly. However, the 95% firm resource level does not continue rising as the degree of innovativeness approaches moderate degrees. A notable feature is that, as the level of innovativeness increases, the level of proactiveness from which the probability of failure reaches one falls gradually. This result implies that, as the degree of innovativeness rises, the speed at which the probability of failure ascends from zero to one accelerates. This result corresponds to the finding in Figure 5.15 that as the degree of innovativeness increases, the thresholds of proactiveness separating the three growth modes fall gradually. This means that the interaction effect between innovativeness and proactiveness found in the absence of risk still exists and still stands at the presence of low risk-taking.

Under the condition of low risk-taking, the highest upper 95% resource stock level occurs when innovativeness is at low and proactiveness is at a high level. Although in this case the probability of firm failure is low, the rate at which the probability of failure increases due to the increase in innovativeness is very high. Under this circumstance, a small degree increase in the level of innovativeness could lead to a big leap in the chance of firm failure.

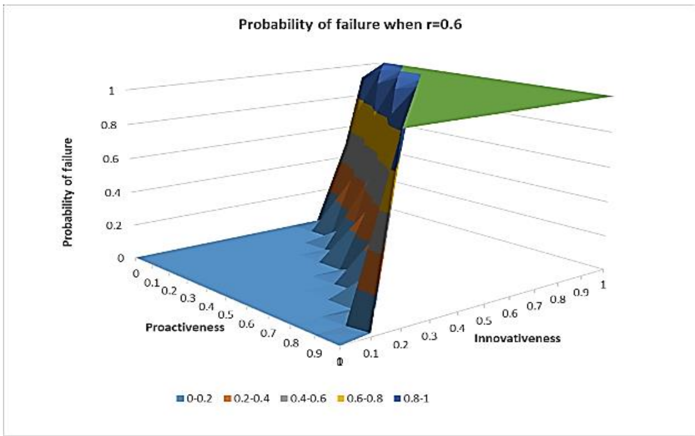


Figure 5.44 The interplay of innovativeness and proactiveness and the likelihood of firm failure when risk-taking is at a moderate level of 0.6

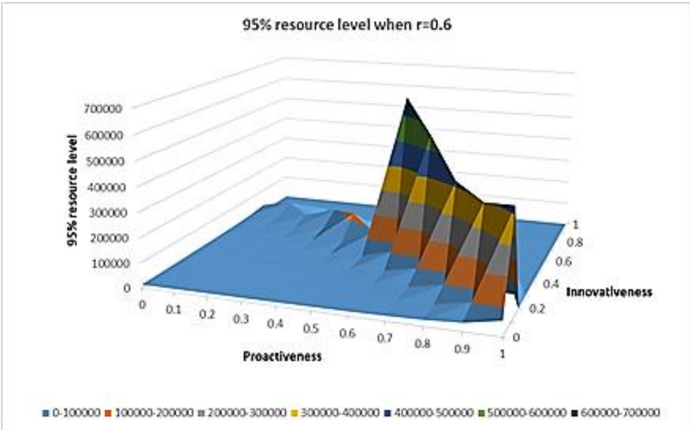


Figure 5.45 The interplay of innovativeness and proactiveness and firm growth when risk-taking is at a moderate level of 0.6

Figure 5.44 and Figure 5.45 show the probability of firm failure and the upper 95% resource stock level respectively at different combinations of proactiveness and innovativeness when risk-taking is at a moderate level of 0.6. The probability of firm failure figure has a similar surface as that when risk-taking is at a low level of 0.3. When proactiveness or innovativeness is at very low levels, the firm growth mode is stagnation. As proactiveness or innovativeness increases, the probability of failure increases accordingly. When innovativeness is at high levels, firm growth collapses. A difference that is easy to go unnoticed is that the probability of firm failure when risk-taking is at 0.6 increases at a relatively slower rate as innovativeness increases than that when risk-taking is at 0.3. We could see that generally the firms have lower growth potential when risk-taking is at 0.6 than that when risk-taking is at 0.3. Under this condition of moderate risk-taking, the highest growth potential occurs when both innovativeness and proactiveness are at moderate levels.

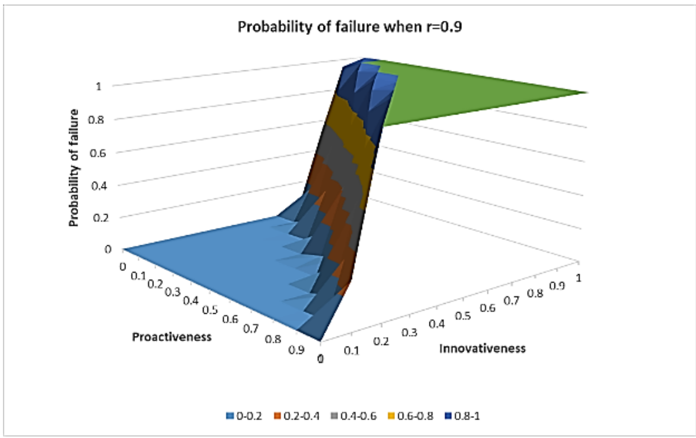


Figure 5.46 The interplay of innovativeness and proactiveness and the likelihood of firm failure when risk-taking is at a high level of 0.9

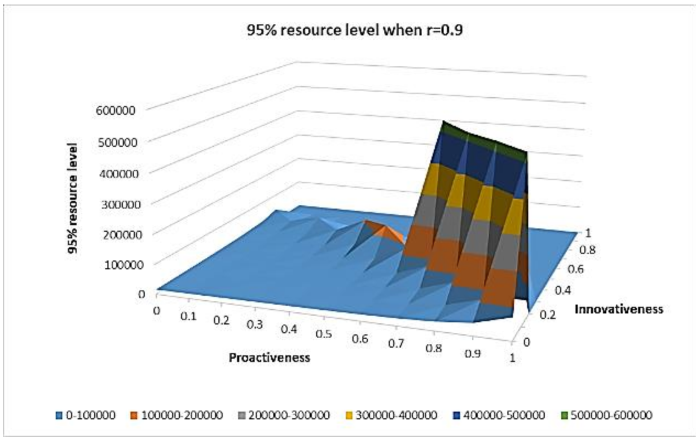


Figure 5.47 The interplay of innovativeness and proactiveness and firm growth when risk-taking is at a high level of 0.9

Figure 5.46 and Figure 5.47 show the probability of firm failure and the 95% resource stock level when risk-taking is at a high level of 0.9. The probability of firm failure figure exhibits an identical shape as those of risk-taking at 0.6 and risk-taking at 0.3 cases. However, the rate at which the probability of failure increases as innovativeness rises is even slower than that when risk-taking is at 0.6. The previous findings that when innovativeness is too low or too high, or when proactiveness is too low there will not be long-term high growth still hold under the condition of high risk-taking. The 95% resource stock figure produced by high risk-taking shows a similar landscape to that of moderate risk-taking. Like the case of low risk-taking, the highest upper 95% resource stock levels among the different combinations of innovativeness and proactiveness occur where proactiveness is at high levels and innovativeness is at low levels. Unlike the low risk-taking and the moderate risk-taking cases, these highest 95% resource stock level form a flat surface, rather than a single peak. The highest 95% resource stock level is in a smaller scale than that of risk-taking at 0.6 case.

However, at the same conditions of innovativeness and proactiveness, the probability of firm failure is, in general, higher than that when risk-taking is at moderate or low levels.

5.3.4. The Mechanism behind the Effects of Risk-taking: Risk-taking and Path Dependence in Firm Growth Process

Simulation experiments in this study uncover some new findings with regard to the effect of risk-taking on the firm growth process. Existing theories largely associate high risk with high potential downside losses and correspondingly high variability in potential payoffs. This conceptualization is adopted as an input into the model. However, it turns out that at the presence of other organizational processes, firm growth is not affected in the same way as risk-taking behaviour is conceptualized.

This study shows that the duality effect of risk-taking is dependent on how innovative and proactive the firm is. When the firm is growing slowly because of innovativeness and proactiveness, high risk-taking could increase the variability in firm growth, i.e. simultaneously elevating the probability of firm failure and the scale of growth for surviving firms. When the firm is having high growth because of innovativeness and proactiveness, high risk-taking, however, could lift the probability of firm failure without elevating the scale of firm growth. An examination of the model structure and model behaviour shows that a central mechanism behind the effects of risk-taking is that unexpected random events could trigger the change of direction of the reinforcing loops in the firm growth process, creating a path dependence process for firm growth.

Path dependence process is defined as "a pattern of behaviour in which small, random events early in the history of a system determine the ultimate end state, even when all ends states are equally likely at the beginning" in Sterman (2000, p. 349). The path dependence literature recognizes two conditions as essential for producing path dependence behaviour, i.e. the possibility of accidental events and the existence of positive feedback loops in the system (Vergne and Durand, 2010). Accidental events trigger the system's inclination towards one particular path rather than the others. These random variations, when occurring in a system dominated by positive feedback loops, will be amplified to significance. The further the process unfolds, the more difficult it becomes to change the course of the system's behaviour, the system eventually locks in.

A widely used example to illustrate the path dependence process is the adoption of the QWERTY keyboard. The QWERTY keyboard is not the best keyboard layout. However, as it is sold more, more typists learn about this layout, and more software developed to suit this particular layout. The increased market share of QWERTY keyboard makes manufacturers of other keyboard designs out of business. As the QWERTY keyboard becomes common, the cost of switching to other keyboard layouts also increases accordingly. The keyboard market eventually is dominated by this particular design, which has no particular merit over its competitors. Another interesting example of path dependence process is the two raindrops falling above the continental divide of North America. Although the two raindrops fall only marginally apart off the clouds in the beginning, under the influence of the direction of the winds, one of the raindrops falls into Pacific while the other one ends up far away in the Gulf of Mexico.

In the case of the simulation of this study, the random events brought about by risk-taking when coupled with the reinforcing growth loop in the system gives rise to the path dependence process in firm growth. The firm, which unfortunately suffers from a series of setbacks from the beginning, has reduced resource availability to support exploration and exploitation activities, which in turn leads to further decline in growth. As firm growth declines, the firm’s ability to absorb future unexpected losses also diminishes. The more the firm declines, the more difficult it becomes to pull the firm out of this downside spiral. On the contrary, with the same resource endowments and EO condition, the firm, which luckily experiences a series of good returns from entrepreneurial activities, has increased resource availability for exploration activities as well as enhanced ability to exploit existing innovations. The positive firm growth loop dominates the system. The greater the growth in the current period, the greater the chance of growing more in the next period.

As the firm accumulates more resources, its ability to absorb unexpected losses also improves (Levinthal, 1991; Plambeck, 2012). Therefore, the more the firm grows, the smaller the effect future unexpected losses have on its growth. The bigger the variability in the payoffs from the entrepreneurial process, the more likely the firm encounters big losses and gets trapped by the vicious circle of decline. At the same time, the firms that do grow out of the dominance of the virtuous firm growth loop could grow more than they do if they did not take such high risks. In this situation, consistent with its operationalization, risk-taking behaviour shows duality effect on firm growth, that is, high risk-taking causes simultaneous high probability of failure and high growth potential. However, further simulations show that this duality effect of risk-taking does not hold on all occasions.

There exists another reinforcing loop in the system—the reinforcing opportunity identification loop. This reinforcing loop is a central element of the motor behind exponential firm growth. However, if it is employed excessively, it will reduce firms' resource slack and increase firms' vulnerability to risks. The strength of this reinforcing loop is positively affected by the proactiveness and innovativeness of the firm. Under the circumstances that the firm is highly proactive and innovative, the increased strength of this reinforcing loop will deplete the resource base of the firm, reducing the resources available for exploitation activities, and making the firm prone to unexpected losses (Plambeck, 2012). Under the circumstances that this reinforcing opportunity identification loop is very strong, the firm's resource stock will be highly strained. Under this condition, even the slightest unexpected loss could force the reinforcing growth loop into a vicious cycle of decline. Thus, in this case, high risk-taking will increase firms' chance of failure without raising the firms' growth potential—the double-edged sword of risk-taking is reduced only to the damaging edge.

The existence of path dependence process in daily life and in businesses is far more than we realize. Entrepreneurship scholars have already suggested the existence of path dependence process in the entrepreneurial process. For example, field study by Danneels (2002) reveals that product innovation creates path dependence in the evolution of firm competencies, which in turn influences the firm's success of product innovation. Alvarez and Busenitz (2001) argue that the entrepreneurial discoveries are path dependent as the Schumpeter new production function is generated from the existing known buddle of production function. In the same vein, the identification of new productive opportunity in the Penrose theory is also on the basis of the firm's existing resources.

These findings also find support in the firm growth literature which suggests that firm growth is nonlinear and prone to interruptions (Garnsey, Stam and Heffernan, 2006). The finding in this dissertation on the existence of path dependence in firm growth process complements with the existing literature through the elicitation of the mechanism underlying firms' vulnerability to setbacks.

5.4. Model Validation

5.4.1. Model Validation in System Dynamics

The nature of model validation in System Dynamics models differs from the validation in statistical models and from other simulation models. Model validity in empirical research using statistical model could be demonstrated by some parameters like the Cronbach's alpha and R square. In System Dynamics modelling, however, no single test could adequately 'validate' a system dynamics model (Senge and Forrester, 1980). This is because there is no way to prove that a model is a 'correct' representation of the reality, not even Einstein's theory of relativity. No model could represent the true world as it is, not only because the real world is highly complicated but also because we human beings are not fully aware of the rules of the world we live in. In this sense, no model is an absolute replication of reality. Nevertheless, this does not mean model is not useful. The judgmental rule for the value of a model lies not so much in if the model is true but more in if it is useful to improve our mental model and our understanding.

Nevertheless, the fact that all models are incomplete does not refute the necessity of model validation and testing. The modeller's task is to build and choose the best model at hand while acknowledging its limitations. As the model passes more and more tests, the modeller gradually builds confidence in the models' soundness and usefulness. Validation in SD models involves more forms than merely numerical tests. The following are the commonly used validation tests in System Dynamics modelling method. I will explain the purpose of each test and how it is conducted in this study.

Model behaviour reproduction validation: The most intuitive and the simplest test to examine the validity of a model is to see if it could produce model behaviour consistent with that observed in the real system. In System Dynamics models built by drawing on case study, a common method is to demonstrate that the model could produce behaviour consistent with the specific cases studied. After fitting the simulated data against the historical data, researchers typically will calculate some model discrepancy statistics such as goodness of fit to show that this replication is well enough (Walrave, van Oorschot and Romme, 2011). However, it is well recognized that this point-by-point replication of historical data is a not an effective validation test, not only because the replication is limited to only one or a few individual cases, but also because its limited power in predicting the future—replicating the past and predicting the future are two capabilities that are not always positively connected. It is insufficient for a model of firm growth to only explain how one particular firm grows in the past. In addition, by doing this it is assuming that the model is a completely correct representation of the reality, which as mentioned above, is unrealistic in the majority of cases.

The multiple-mode test, which in contrast considers whether the model could produce multiple modes of behaviour generally seen in reality, is an important behaviour test. A model that produces different modes of behaviour observed in reality makes it possible to investigate how different policies lead to different behaviour. It also enables the researchers to explore how the transition among the different modes happens. As is also explicitly put in Penrose (1959, p. 4) "A comprehensive theory of the growth of the firm must explain several qualitatively different kinds of growth…".

Therefore, in this study instead of calibrating the model behaviour against any individual case of firm growth, I performed the model behaviour test by showing that the model successfully produced some typical patterns of firm growth process, such as growth stagnation, exponential growth, early firm collapse, overshoot, and collapse. These different growth modes produced by the model in this study are consistent with the growth paths identified in Garnsey, Stam and Heffernan (2006) using data of technology firms over a ten-year period in Cambridge, German, and the Netherlands.

Model structure validation: Having the model producing the behaviour or problem consistent with reality is not enough, because the same behaviour could be produced by different structures. We need to ensure that the model produces the 'right behaviour' out of the 'right reason'. The purpose of model structure test is to verify that the model structure is consistent with the theory or with the real system that the model is intended to stand for. This involves directly comparing the structure of the model with the real system that the model represents. As the model in this study is built by referring to existing theories in a repeat process, every 'variable' and every relationship in the model could be found in the existing literature. I focus on the pieces of structure that are most important and relevant for understanding entrepreneurial process. The model structure in this study has also been checked that it conforms to the laws of conservation.

Extreme condition test is a very powerful and widely used test to discover flaws in the SD models. It involves setting model variables into extreme values and observing if the system behaves in plausible ways, although this extreme scenario may not occur or exist in reality. For example, in the current model if the productive opportunity set falls to zero, the innovation rate would also have to be zero; if the firm resource stock goes to zero, the innovation delay would go to enormously large; the productive opportunity set and the innovations stock could never drop below zero no matter how resource constrained the firm is. This study conducted a number of such tests—I traced each rate variable of the model to the stock variables that it depends, considered the different extreme conditions of the stock variable and examined if the model behaved as expected. These tests were conducted for each piece of model structure and to the model as a whole. The model passed all these extreme condition tests.

Model boundary adequacy test involves making sure the model structures necessary to the model purpose are included in the model.

Model parameter verification: The model parameters, i.e. constants, correspond both conceptually and numerically to those in the existing literature. As mentioned before, the model parameters are from existing literature and parameter values are assigned by drawing on existing studies and empirical datasets.

Model dimensional consistency means the units in model equations, both in single equation and equations in the model as a whole, are consistent. It is a straightforward test, but it could reveal serious flaws in the modellers' understanding of the model structure. The current model is unit consistent and no 'scaling' parameter is used to deliberately make the units consistent.

Time step and time span of simulation: Unlike discrete event modelling, the SD model has the assumption that changes happen continuously over time. The calculations of the SD method are conducted at every small time interval. There will be problems in the simulation results if the time step is too big relative to the model constants. To avoid the potential integration errors caused by a large time step, this study adopts a very small time step, DT=0.015625. At the same time, simulations in this study use a long time horizon, i.e. t=500 months, to make sure that the simulation results are not unique to any short-term time horizon.

Sensitivity Analysis examines whether the model behaviour is robust to uncertainties in the model. However, having sensitive parameters does not mean the model is invalid. Rather, it informs researchers of the highly leveraged policy points and which parameters need to be paid more attention to when collecting empirical data. A parameter around which no uncertainty exists needs not to be tested, even if the model behaviour is highly sensitive to it. Likewise, if a parameter has but little effect on the dynamics of the system it need not to be tested even if its value is highly uncertain.

5.4.2. Replication of Firm Size and Firm Growth Rate Distributions

The fact that this model can produce the commonly seen firm growth trajectories has already to some extent demonstrated its validity (Senge and Forrester, 1980; Rudolph, Morrison and Carroll, 2009; Walrave and Raven, 2016). To enhance the confidence in the validity of the model, I further conducted 2000 simulation runs with different EO conditions in attempt to see if the firm size distribution derived in the simulation is consistent with that observed in reality. That firm size distribution conforms to skewed long tail distribution is a well established and robust finding in the firm growth literature. This long tail firm size distribution has been demonstrated to be regardless of country, sector, and time (Hernández-Pérez, Angulo-Brown and Tun, 2006; Zou, 2019). The following figures show the firm size distribution produced by the simulations of this study. The simulations clearly give rise to the skewed long tail firm size distribution.

Figure 5.48 Frequency of firm resource level distribution in the end of the simulation

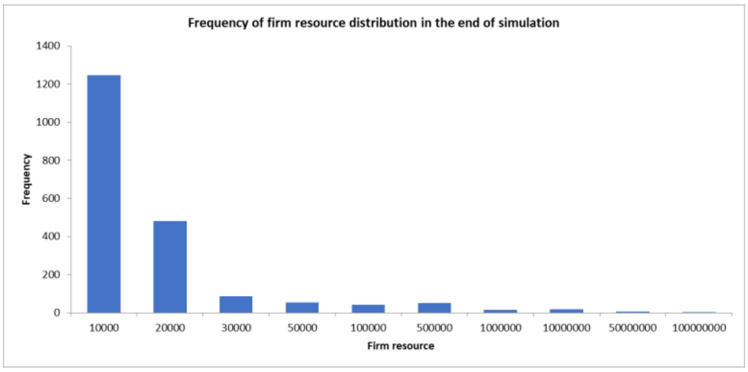
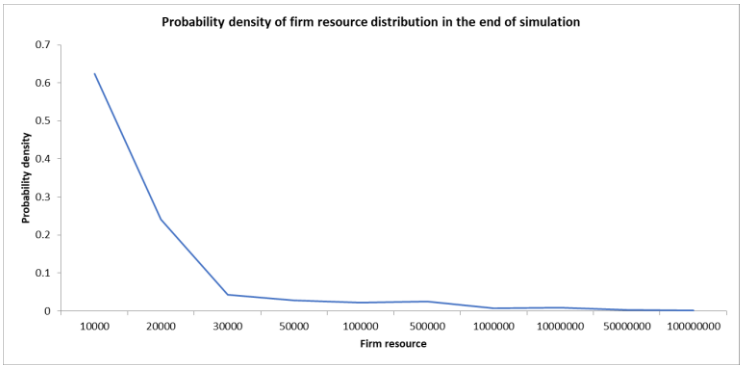


Figure 5.49 Probabilty density of firm resource level distribution in the end of the simulation



Studies using different databases have also universally identified that the probability density of firm growth rates has a tent-shape, which is usually described in a Laplace form, e.g. the double exponential distribution form (Bottazzi and Secchi, 2003, 2006;

Coad, 2007; Zou, 2019). The following two figures show the growth rate distribution produced by simulations in this study, which replicates the tent-shape distribution.

Figure 5.50 Frequency of firm growth rate distribution in the end of the simulation

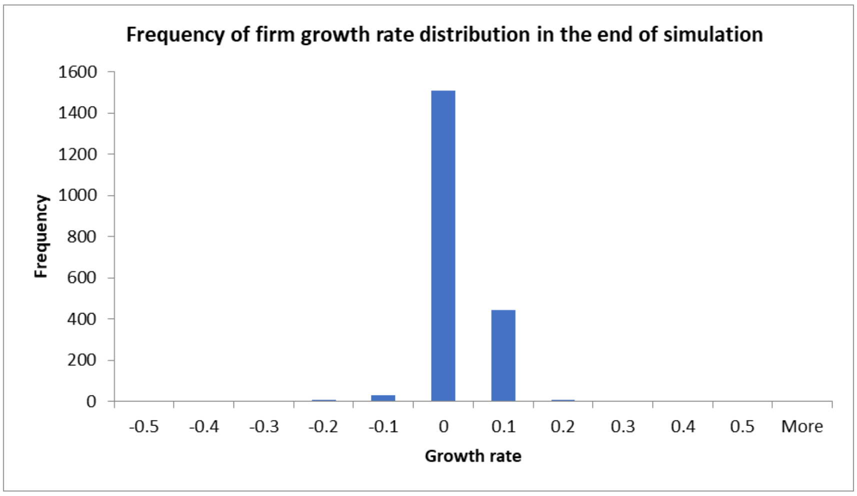
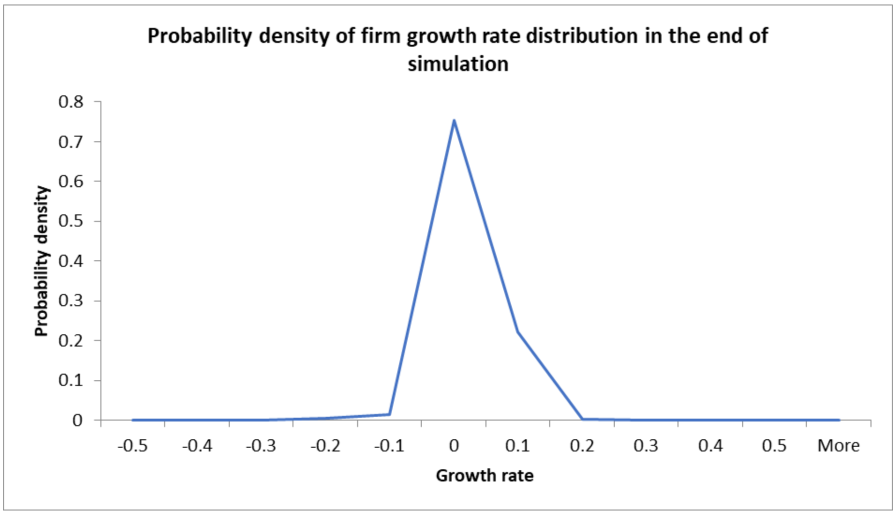


Figure 5.51 Probability density of firm growth rate distribution in the end of the simulation



Chapter 6. Summary and Conclusions

6.1. Summary

The majority of entrepreneurship studies have focused on the performance of firms as the empirical phenomenon of investigation. As Shane and Venkataraman (2000) point out, firm performance is neither a unique or a sufficient measure of entrepreneurial performance, because firm performance has been the focus of strategic management scholars and the opportunity cost of other options weighs out the temporary performance benefits. By adopting a process approach, this study aims to uncover how entrepreneurial processes unfold within firms and how these processes lead to firm growth in the long term.

As a foundation, this study uses the Penrose's theory of the firm growth process, which has been influential in the firm growth literature in bringing attention to the generative mechanism behind firm growth processes. The Penrose theory focuses on the roles of firm resources and firm's uses of resources to achieve growth through the pursuit of new productive opportunities. This study combines the entrepreneurial orientation literature with Penrose's theory to explicate the process mechanism that generates firm growth. Entrepreneurial orientation represents a strategic orientation that dictates how a firm pursues entrepreneurial opportunities and, as such, provides a good combination with Penrose's foundational theory to explain the generative mechanism behind firm growth process.

I did not adopt the traditional approach—by either providing new data, coming up with new constructs or testing the relationship between two variables. Instead, all the variables and relationships in the model are from existing literature and practices, which when taken together in a holistic way, produce new insights. Through reviewing existing literature from a feedback perspective, I discovered some key feedback processes involved in the firm growth process. These feedback processes, especially their interactions, are crucial to the dynamics of the firm growth process. The model produces trajectories of firm growth commonly seen in reality, such as growth stagnation, exponential growth, early failure, as well as overshoot and collapse. These different behaviours are jointly produced by the physical structure of the firm growth process and the decision making styles the firm adopts to conduct the entrepreneurial process. By associating model behaviour with model structure, the simulation analysis unveils a consistent process theory that has roots in prior literature but provides new process insights.

Firstly, this study synthesizes the Penrose theory with key frameworks in entrepreneurship studies to develop a model that depicts how entrepreneurial processes unfold within firms and how they lead to firm growth over time. The modelling process reveals that both the entrepreneurial process and the firm growth process are composed of feedback loops. Entrepreneurial opportunity identification process and exploitation process do not connect in a linear fashion. Rather, the opportunity exploitation process leads to the identification of new opportunities. This link completes a reinforcing loop between opportunity identification and opportunity exploitation. Opportuntiy drives action, actions generate new information and knowledge, which spur the creation of new ideas. This reinforcing process is not only indicated in the Penrose theory, but is also implied in entrepreneurship studies.

This reinforcing loop could lead to a growing productive opportunity set and is the main component of the engine driving exponential firm growth. The productive opportunities give rise to new lines of business that generate revenue streams for the firm, which can be invested into the exploration of new ideas. Thus firms could grow over time in a virtuous cycle. However, reinforcing loops could also work as vicious cycles. The existence of long time delay in the entrepreneurial payoff means that over-commitment into new and uncertain projects could impose heavy resource pressure on the firm, which may damage firms' ability to exploit existing innovations. Without the funds from exploitation activities, the firms face increased delay in the innovation projects and reduced capability to conduct either exploration or exploitation activities. The original virtuous firm growth loop starts to change direction and drives firms towards a vicious spiral of decline.

Secondly, the three dimensions of EO dictate how the subprocesses of the entrepreneurial process are conducted. The system produces multiple behaviour patterns under different EO conditions, suggesting that the entrepreneurial process could lead to fundamentally different firm growth trajectories depending on how this process is conducted. The simulation analysis in this study further shows that the relationship between entrepreneurial orientation and firm growth is far more complex than the existing studies suggest. Consistent with prior findings (Wiklund, 1999), this study finds that the effect of EO on firm growth is not temporary, but long-lasting. However, the short-term growth consequences of EO could be different from those of the long term. The simulation shows that after adjusting to a new level of EO, there exist the better before worse and worse before better dynamics in firm growth and that it takes a significantly longer time than we normally assume for the true long-term effect of EO to reveal. Given that existing empirical studies normally collect data on firm growth one or two years after gathering the data of EO, whether the growth consequences of EO have been correctly understood is in doubt.

This study further shows that while firms need at least some degree of innovativeness to get away from the growth stagnation, being over innovative could result in sudden growth collapse. This result in general is consistent with findings from existing literature that too much innovation is detrimental to firms' long-term growth (Barnett and Freeman, 2001), and that the relationship between innovativeness and firm growth to some degree resembles with the inverted U relation found in the empirical studies of EO (Tang et al., 2008; Wales et al., 2013). However, this study unveils some novel insights. In particular, this study finds that the relationship between EO and firm growth does not conform to the traditional linear and proportional thinking, where one unit change in EO would lead to some proportionally corresponding units of change in firm growth rate. Rather, simulation experiments in this study indicate that the relationship between EO and firm growth is better described by the notion of "tipping point"—the existence of critical thresholds that once surpassed will cause radical changes in the system behaviour in the long term.

Consistent with the emerging EO as experimentation perspective (Wiklund and Shepherd, 2011), this study finds that the same EO condition has different implications for firm growth and for firm survival. It is counterintuitive to think that risk-taking could elevate the potential scale of firm growth while simultaneously increasing the chance of firm failure. Although the existing studies have indicated this variance amplifying, rather than mean amplifying effect of EO (Wiklund and Shepherd, 2011; Patel et al., 2015), the underlying mechanism behind EO's contradictory effects on firm growth and on firm survival has remained unclear. By adopting a process approach, this study elicits the mechanism behind this duality effect of risk-taking: that the random events brought by risk-taking when coupled with the reinforcing firm growth loop give rise to path dependence process that magnifies the consequences of unexpected gains and losses. However, this study reveals new insight that this duality effect of risk-taking does not stand on all occasions—the effect of EO on firm growth is dependent on how innovative and proactive the firm is.

Thirdly, one important finding of this study is that there exist complicated interaction effects among the three dimensions of EO on firm growth. The simulations show that the effect of one dimension of EO on firm growth is dependent on the two other dimensions. The three dimensions of EO work in different parts of the model. But as the entrepreneurial process unfolds over time, the effect of one dimension feeds back into the other through the various feedback loops in the process, forming interesting interaction effects among the three dimensions. A large number of simulations have been performed to understand how the three dimensions of EO interact to affect firm growth. The next section elaborates how the three dimensions exactly interact to affect growth and the existence of the optimal dimensional configuration of EO for firm growth.

6.2. A Tale of Three Dimensions

6.2.1. The Intervening Role of Proactiveness and Risk-taking on the Effect of Innovativeness on Firm Growth

The simulations show that the inverted U shape relationship between innovativeness and the upper 95% level of firm growth holds under different conditions of proactiveness and risk-taking. However, the exact shape, position, and scale of the inverted U shape relation between innovativeness and the 95% level of firm growth vary across different levels of proactiveness and risk-taking. At a given level of risk-taking, proactiveness mainly influences the shape and position of the inverted U shape relation between innovativeness and the 95% level of firm growth. At a given level of proactiveness, risk-taking mainly influences the scale, i.e. the level of the 95% growth arrived out of innovativeness.

However, the relation between innovativeness and the probability of firm failure does not conform to the inverted U shaped relation. At given levels of proactiveness and risk-taking, a higher level of innovativeness always leads to an increased chance of firm failure. Moreover, at a given level of risk-taking, with the level of proactiveness rising, the rate at which the likelihood of failure increases due to the increase in innovativeness accelerates. Counterintuitively, at a given level of proactiveness, with the level of risk-taking rising, the rate at which the likelihood of firm failure increases due to the increase in innovativeness decelerates. These results have twofold implications. Firstly, although proactiveness and risk-taking cannot alter the positive relationship between innovativeness and firm's likelihood of failure, they could alter the rate at which the likelihood of firm failure increases due to increasing innovation commitments. Secondly, these results suggest that proactiveness and risk-taking impose different, sometimes opposite influences on the innovativeness and firm failure relation.

6.2.2. The Intervening Role of Innovativeness and Risk-taking on the Effect of Proactiveness on Firm Growth

This study further finds that to escape growth stagnation, it is not enough to be only innovative—firms also need to possess at least some degree of proactiveness. Under the condition that the firm exhibits a very low level of innovativeness, being more proactive always leads to higher growth in the long term. Under the condition that the firm is extremely devoted to innovation, being more proactive leads to worse growth. When the firms do not go to extremes in terms of innovativeness, proactiveness shows an inverted U shaped relationship with the 95% level of growth achieved—although the exact shape and position of this inverted U shaped relation vary across different levels of innovativeness. One implication from this is that, it seems innovativeness and proactiveness do not exert identical influences over each other's relation with firm growth. Similar to the case of innovativeness, risk-taking mainly influences the scale of the highest growth arrived out of proactiveness.

As confirmed by a large number of experiments, there exists an interaction effect between innovativeness and proactiveness on firm growth and this interaction effect holds under different conditions of risk-taking. The experiments show that the thresholds of innovativeness that distinguish different growth modes are dependent on how proactive the firm is. Likewise, the thresholds of proactiveness that distinguish different growth modes are dependent on how innovative the firm is. As innovativeness increases, the levels of proactiveness at which exponential firm growth occurs tend to fall down. Similarly, as proactiveness increases, the levels of innovativeness at which exponential growth happens also tend to fall down. Nevertheless, both dimensions are necessary, i.e. need to be above some minimum degrees, for long-term sustained growth to occur. These results seem to suggest that the relationship between innovativeness and proactiveness is neither purely complementary nor purely substitutive, but a mixture of the two.

6.2.3. The Intervening Role of Innovativeness and Proactivenss on the Effect of Risk-taking on Firm Growth

With the interaction effect between innovativeness and proactiveness and their effects on firm growth in mind, I then analysed how the different growth patterns produced by innovativeness and proactiveness are altered under different conditions of risk-taking behaviour. Simulation analysis shows that risk-taking could turn some of the growth stagnation and exponential growth generated by innovativeness and proactiveness into collapse, and the bigger the risks taken, the more likely the collapse happens. However, risk-taking is unable to turn the stagnation or collapse pattern generated by innovativeness and proactiveness into exponential growth. In addition, risk-taking is also found to have some influence on the interaction effect between innovativeness and proactiveness. For example, the thresholds of innovativeness and proactiveness above which firm collapse changes from a probabilistic event to a deterministic event go lower as risk-taking increases. This means, the exact thresholds of innovativeness and proactiveness upon which firm collapse becomes an absolute event is not only determined by how innovative and proactive the firm is, but also by how much risk the firm takes.

Risk-taking is operationalized according to its commonly used definition "the higher the risk, the bigger the potential of downside cost and the variability in the payoff". Consistent with this definition, an initial set of simulation runs show that the higher the risk, the higher the probability of firm failure and the higher the scope of growth for the surviving firms. However, as I continue to investigate the effect of risk-taking under different combinations of innovativeness and proactiveness, a new finding is that risk-taking does not always affect firm growth in the way as it is defined. Specifically, a detailed analysis of the simulation runs reveals that when firms grow at an exceptional rate because of being innovative and proactive, risk-taking will elevate the chance of firm failure without lifting the variance in firm growth. This means the "good edge" of high risk-taking in improving the scale of firm growth is gradually damaged as the level of innovativeness or proactiveness rises.

Further examination of the model structure and the model behaviour unveils the mechanism behind the varying effect of risk-taking: As mentioned earlier, the randomness brought by risk-taking when coupled with the reinforcing growth loop creates path dependence process. Under the circumstances that the firm is excessively committed to innovation and proactivity, the massive resource consumption will diminish the firm's resource slack (Kiss, Fernhaber and McDougall-Covin, 2017), which makes firms susceptible to unexpected losses in the entrepreneurial process (Nohria and Gulati, 1996). As firms make use of their resource stock to pursue growth, a series of bad payoffs (bad lucks) may trigger the change in the direction of the reinforcing firm growth loop, locking the firm into a vicious cycle of decline. Under the circumstances that the firm is highly resource strained, even the slightest deviation from the expected payoff is sufficient to trigger the change in the direction of the growth loop and trap the firm into a path-dependent process of decline. Thus, in this case, the risk-taking loses its power of improving the scope of the growth.

The simulation results therefore suggest that the optimal level of risk to take is contingent on how innovative and proactive the firm is. The higher the growth brought about by being innovative and proactive, the more weakened is the firm's ability to absorb unexpected losses and the more susceptible the firm is to risk. These results find some support in the existing empirical studies. For example, Hyytinen, Pajarinen and Rouvinen (2015) find that the interaction of innovativeness and high risk-taking leads to reduced prospect of firm survival.

6.2.4. The Optimal Dimensional Configuration of EO for firm growth

Through extensive simulation, this study plots the long-term growth outcomes out of different configurations of the three dimensions of EO. Despite some differences, the figures of the probability of firm failure show similar landscapes for low, moderate, and high risk-taking. The situation for the 95% level of firm growth plots, however, is a bit different. For the 95% level of firm growth plots, the moderate risk-taking and high risk-taking share a similar landscape, while the low risk-taking produces a growth landscape that is at a significantly larger scale than those of moderate and high risk-taking.

The simulation shows that firms with a high degree of proactiveness, and low degrees of innovativeness and risk-taking have very high growth potential with relatively small likelihood of failure. Nevertheless, this does not mean that this particular EO dimensional configuration is the optimal configuration. Although at this particular EO dimensional configuration, the probability of failure is not very high, the rate of change in the probability of failure is very high. In this situation, a little bit increase in the level of innovativeness could dramatically increase the firm's chance of failure.

The interactions among the three dimensions result in nonlinearly complicated EO-firm growth landscapes where incremental changes in one dimension of EO will normally only result in a local peak of the 95% level of growth. Improvement in long-term firm growth usually derives from simultaneous adjustments in the three dimensions of EO. In this sense, the ongoing discussion in the EO literature regarding whether the three dimensions of EO could vary independently or not perhaps should be shifted to a question of whether they should vary independently or not.

Studies on path dependence process suggest that only simulation method could really reveal and test path dependence process (Vergne and Durand, 2010). This study is one of the few studies that apply process approach and computer simulation method to the EO research so far. It contributes to our understanding of the random and deterministic mechanism that in most cases it is the interplay between the two that determines the evolutionary process of a firm.

6.3. Theoretical Implications

6.3.1. Theoretical Implications for the Entrepreneurial Process within Firms

Entrepreneurship enables firms to recombine resources at hand for new products or services to counteract environmental constraints and to achieve sustained growth (Penrose, 1959; Baker and Nelson, 2005). This study aims to improve our understanding of how these processes are conducted within firms and how these processes will lead to firm growth. In so doing, this study seeks to advance theoretical development on entrepreneurship within firms. EO is one of the theoretical lenses proposed to explain how entrepreneurial processes proceed within firms (Miller, 1983; Lumpkin and Dess, 1996). However, this concept of EO has been almost exclusively used to represent the characteristics of a firm instead of a process. This study stands as the first, according to the author's knowledge, to respond to EO scholars' call for investigating EO as a process (Wiklund and Shepherd, 2011). Building on the entrepreneurial process framework by Shane and Venkataraman (2000) and relevant entrepreneurship studies, this study constructs a process model of entrepreneurship within firms, where EO is manifested through the firms' entrepreneurial process and behaviour.

Although existing studies normally investigate the stages of entrepreneurial opportunity identification and exploitation separately or as linear progression, as if they were in temporarily sequential order (De Jong, 2013). An examination of the literature shows an increasing realization of the entrepreneurial process as a nonlinear process characterized by feedback loops. For example, in the field study of entrepreneurial bricolage by Baker and Nelson (2005, p. 347):

> "A mutually reinforcing pattern appeared to characterize several elements of parallel bricolage. …Engaging in new challenges allowed members of firms to increase the range of their self-taught skills, and this, in turn, further broadened the range of problems and opportunities that the firms were willing to tackle through bricolage. Several characteristics of these mutually reinforcing processes appeared to make it unlikely that firms engaged in parallel bricolage would grow."

And in Stevenson and Jarillo (1990, p. 25): "The fact, moreover, that they are not strictly independent but, rather, reinforce each other (someone who is willing to pursue opportunities will 'see more' of them; someone who is confident in his/her ability to succeed will be more willing to pursue them; etc.)."

While the existence of this reinforcing loop in the entrepreneurial process and its damaging effect for firm growth have been recognized, how exactly the feedback loop works, how it interacts with other organizational processes, as well as its dynamic implications for firm growth warrant more investigation. Qualitative understanding is not sufficiently informative because reinforcing loops may exist in a system but may not always dominate the system behaviour. Using formal modelling and taking advantage of the computer simulation method, this study shows that entrepreneurial firms face thresholds in terms of the degrees of their innovativeness and proactiveness, beyond which the firms' growth dynamics will be fundamentally changed and firms' capabilities to respond to new opportunities will be seriously eroded. When operating under this threshold, the reinforcing firm growth loop dominates as a virtuous circle driving firms to grow exponentially, but once this threshold is exceeded, the firm is trapped into a vicious cycle of decline. This damaging effect of the reinforcing loop in the entrepreneurial process is indicated in Baker and Nelson (2005, p. 347):

> "In addition, engaging in multiple novel projects consumed large amounts of time and attention for the processes of learning, experimentation, and fabrication that bricolage often involves and also for the extended period of "coaxing"—the ongoing attempts to get additional service out of worn, failing, or obsolete resources—that typically accompanies bricolage."

When a forthcoming crisis is due to happen, firms often do not recognize it until it is too late. This problem is a joint outcome of the nonlinearity in the system and the rapidity of collapse once it happens. When the system is operating under the tipping thresholds of innovativeness and proactiveness for collapse, the reinforcing growth loop works as a virtuous circle. Firms therefore learn through the action-outcome relation that being more innovative or proactive will always lead to better growth in the long term. As time goes by, firms become increasingly obsessed with the weapon of entrepreneurship and more confident of their ability to control the entrepreneurial process. This echoes with the field study in Baker and Nelson (2005, p. 331):

> "Having used bricolage to escape the constraints of a penurious resource environment, these firms appeared to have created a set of interlocking behaviours and expectations that kept them on the path of parallel bricolage. Bricolage, in the process of countering the social psychological processes of enactment (Weick, 1979), had created an objectified and constraining social structure (Porac, Thomas, and Baden-Fuller, 1989; Aldrich, 1999) that was taken for granted by most participants."

The field study in Baker and Nelson (2005, p. 357) also suggests the detrimental effects caused by this reinforcing loop:

> "The refusal to enact environmental limitations helps firms use bricolage to create something from nothing. We found, however, that when this is taken to an extreme—as when the firms engaged in parallel bricolage repeatedly attempted to create something from nothing across multiple domains—identities and communities of practice that are constructed create a new set of limitations that suppress growth. In contrast, when firms use bricolage more narrowly or temporarily, first rejecting and then

> enacting environmental resource limitations, they appear to be more likely to grow."

When the tipping thresholds are crossed, the reinforcing growth loop starts to work as a vicious cycle that leads to declining growth. The once well-functioned mechanism suddenly becomes out of control. This tipping point behaviour comes out of the interplay between two reinforcing feedback loops in the system: the reinforcing feedback loop in the entrepreneurial process and the reinforcing loop in the firm growth process. Reinforcing loops could not only work as virtuous cycle driving firm growth but could also work as vicious cycle driving firm to decline. An insight gained is that the increase in the strength of the reinforcing loop in the entrepreneurial process could lead to the change of direction of the reinforcing feedback loop in the firm growth process. The decline in firm growth will in turn cause a detrimental effect on the entrepreneurial process, forcing the entrepreneurial process to halt. This seems to suggest a co-evolutionary process between the entrepreneurial process and firm growth process.

The above shows that firm decline could occur endogenously through the firms' increased efforts to innovation and proactivity. This study further finds that such firm decline could also be triggered by exogenous shocks. That is, random events, or luck, also play an important role in the entrepreneurial process. A series runs of bad luck could also push the system over the thresholds, triggering the change of direction in the firm growth loop, and quickly damaging firm growth to the point that collapse is almost inevitable. As firms proactively engage with intense innovations, the productive opportunity stock accumulates, depleting the resource base of the firm and the firm's resilience to deal with unexpected events declines. At the presence of a good resource reserve, a series of losses (a run of back luck) may trap the system into a vicious cycle of decline. At the presence of a severely strained resource base, even the slightest payoff deviation could push the system over its tipping point thresholds. This finding could find some implication in existing work, for example in Wales (2015, p. 12), "EO represents a resource intensive strategic posture (Covin and Slevin, 1991). With a greater variance in performance, many firms exhibiting high levels of EO in the pursuit of growth will eventually exhaust their resources, be unable to weather significant downturns, and discontinue operations. ".

There are some discussion on whether the entrepreneurial process is random, deterministic, or chaotic—the seemingly random process generated by a stable and deterministic linear system (Cheng and Van de Ven, 1996). The insight gained through this study is that actually none of the terms is an accurate description of the entrepreneurial process. The fact that random events play an important role in the entrepreneurial process cannot deny the crucial role of deterministic mechanism in the entrepreneurial process. Likewise, the importance of deterministic mechanism in the entrepreneurial process cannot deny the crucial role of random events. It is actually the interplay between the two that gives rise to the distinct growth trajectory of each firm.

The different pieces of the entrepreneurial process are inextricably linked, and connected to other organizational processes, forming a complex system. This study shows how the interactions among these different processes distinguish firms between exponential growth on one hand and stagnation or collapse on the other hand.

6.3.2. On the Role of Randomness in Entrepreneurial Process

Theorizing in the business and management disciplines is largely deterministic and measurable. Einstein says, “God does not play dice with the universe”, which implies events do not happen by mere chance. This study actually agrees with this view. However, there may not be pure random events in the universe, but there indeed are random events from the standpoint of the human being. The fact that this study introduces randomness into this study does not mean that this study considers these processes as purely random. It only means that the things deterministic to the entrepreneurial outcome are far more complicated to be fully incorporated, not only into this study but probably into any study. Randomness in this sense is a good approximation of the complications brought about by factors out of the scope of the study.

Eliciting the entrepreneurial process from a view of complexity system provides us with a new lens to look at random events: that a process endowed with random inputs does not necessarily produce random outcomes. The structure of the system into which the random events occur has no less importance in determining the outcomes of the process than the random events do. It is undeniable that random events play significant role in the evolution of firms’ resource stock (Barney, 1986). However, when random events are combined with the structure of the system, new processes are created, such as path dependence process, which could lead to deterministic outcomes.

6.3.3. The Sources of Heterogeneity in Firms' EO

By employing computer simulation method, this study identifies the configuration of the three EO dimensions that is best for long-term firm growth. A question then arises as to what causes the heterogeneity in firms' entrepreneurial orientation. That is, why do not all firms converge on this best dimensional configuration of EO?

Multiple reasons may account for this. Firstly, as a future-oriented behaviour, no entrepreneurial process is truly risk-free, especially in the contemporary complicated and quickly changing business environment. The fact that luck plays an important role in the entrepreneurial process hinders organizational learning. Besides that, the existence of better before worse and worse before better scenario in firm growth also makes learning difficult. At the same time, the rugged landscape of long-term firm growth outcomes caused by the complicated interactions of the three behavioural dimensions of EO precludes firms from converging on this best EO configuration. Moreover, being aware of the best dimensional configuration of EO for long-term firm growth does not guarantee that this configuration of EO will be adopted and implemented. Because growth out of entrepreneurial process always comes at a trade-off between short term and long term benefits. It may be a psychological bias to sacrifice tomorrow for today (Von Hippel, Thomke and Sonnack, 1999).

Thirdly, this paper takes the stance that EO does not exist just because the firm is willing or wants to be at a certain level of EO, but it also represents a kind of capability. Not all firms that engage with R&D and innovation will come up with innovative combinations. Research has shown that there is a significant firm performance difference between innovation input and innovation output (Rosenbusch, Brinckmann and Bausch, 2011). Similarly, being able to enter the market ahead of competition is also a capability. Likewise, not all firms are capable of gauging the true risks they are taking.

Furthermore, it is not easy to be at a certain level of a certain dimension of EO. It might be even more difficult to be at a certain configuration of EO. This study reveals the existence of interaction effects among the three EO dimensions and investigates the growth implications out of the different configurations of EO. Possibly the interactions among the three dimensions may not only be manifested through their joint impact on firm growth, but also that the firm's stance on one dimension may affect its ability to excel in the other dimension. For example, risk-aversion firms tend to gather as much information as possible to evaluate the opportunity and try to eliminate the associated risk. They tend to wait and see until things become clear. This risk-aversion inclination may therefore impair firms' ability of proactively capturing the opportunity. In this way, the risk-taking dimension and the proactiveness dimension may covary, but in the opposite direction. The literature also suggests that firms' proactivity and risk-taking inclination will influence firms' innovation generation (Pérez-Luño, Wiklund and Cabrera, 2011).

Therefore, although this study suggests firms that act highly proactively, engage with not too much innovation and take small risks would have high growth potential, whether firms could reach that particular dimensional configuration and how to attain that particular configuration are further questions. EO, especially certain configurations of EO, is not something that could be acquired as long as the firm wants, but is also a capability that needs to be carefully cultivated. This then gives rise to a further implication for the discussion of the dimensionality of EO: that it is not only about whether the three dimensions should covary, but are they able to covary? The paradoxes, connections, and contradictions among the three dimensions may be a fruitful area worthy of further investigation in the future. This difficulty of arriving at a certain configuration of EO presents another potential explanation on the heterogeneity of EO across firms.

Lastly, even if firms arrive at the desired configurations of EO, the finding on the tipping point behaviour suggests that it is not easy to maintain it. Firms used to rely on local search and adaptations to find the best strategy are likely to exceed the tipping thresholds (Rahmandad and Repenning, 2016).

6.3.4. Theoretical Implications for the EO Construct

Consistent with existing studies, this study shows that innovation is crucial for firm growth in the long run. Innovative firms are willing to depart from existing practices and embrace experimentation to gain more knowledge about their underutilized firm resources. The information gained in these innovative processes enables firms to generate heterogeneous beliefs about the value of resources than their competitors and enables them to identify new productive uses that might result in new products, processes, or services (Lumpkin and Dess, 1996; Shane and Venkataraman, 2000). This process is critical for firms to break through the growth stagnation or bottleneck. However, innovation activities demand heavy resource commitment and it takes a long time for the value of innovation to translate into financial benefits (Coad and Rao, 2008). This study shows that excessive innovation is likely to lead to firm collapse in the long run.

Findings in this study also underscore the importance of constantly monitoring the environment and being quick to act (Lumpkin and Dess, 2001). Not only being quick to market could reap the many benefits as a first mover (Lieberman and Montgomery, 1988), but also could save significant firm resources in "waiting and see" (Markman et al., 2005). Firms in the contemporary business environment, especially in the high tech industry, all tend to put emphasis on R&D and innovation, but these firms have different destinies. The firms lagging behind in technological development sometimes are not due to the lack of innovative ideas, but due to the lack of initiative to act. The entrepreneurial context is characterized by risk and changes. There will never be a time when everything gets certain. If there is, that will be the time when the opportunity is not an opportunity any longer. Studies have suggested that being late to market has significant financial consequences (Stanko, Molina-Castillo and Munuera-Aleman, 2012). However, first movers with extensive innovation are likely to encounter increased risk as no prior data or experience could be applied in the new area (Engelen et al., 2014). This study further shows that when firms are conducting massive innovations, being highly proactive is not good for long-term growth.

There has been some discussion on the relative importance of the three EO dimensions, with innovation generally considered to be the most important dimension of entrepreneurship (Stevenson and Jarillo, 1990; Moreno and Casillas, 2008). This study finds that all three dimensions are essential for the long term firm growth, although in different senses. The importance of innovation and proactivity lies in enabling firms to grow while the importance of risk-taking lies in how much to grow and how much likely to survive. Risk-taking is also a matter of necessity—under the constantly changing modern business context, there is always a portion of risk irremovable (Penrose, 1959), except when the firm is unable to perceive the risk or turns a blind eye to the risk.

Interestingly, when the three dimensions of EO are at the same level, be it high, moderate, or low, the growth outcomes are usually not the best. Instead, the simulations show that firms with a relatively low degree of innovation, taking small risks but being highly proactive in terms of capturing opportunities have good potential for long-term high growth. Nevertheless, this does not mean that innovation and risk-taking are not as important as proactivity, but that innovation and risk-taking need to be controlled within a certain degree. Because an additional finding of this study is that, out of the same extent of change, innovativeness produces a much greater impact on firm failure than proactiveness does and that this difference is more notable as risk-taking falls. Actually, according to the simulation results, no dimension is truly important in the absence of the two other dimensions. Only when they are configured in a certain way can firms have the chance to grow sustainably in the long term.

Although the unidimensional view of EO suggests that the three EO dimensions are manifestations of an overall entrepreneurial strategic orientation, scholars under the unidimensional view of EO implicitly accept that the three dimensions do not necessarily lie at exactly the same level (Wales, 2015). The majority of EO studies measure EO as the summated score of its different measurement items, under which the differences in the configurations of the three dimensions are covered.

Consider the following conditions of EO: innovativeness at 0.5, proactiveness 0.5, and risk-taking 0; innovativeness 0.2, proactiveness 0.8, risk-taking 0; innovativeness 0.1, proactiveness 0.1, risk-taking 0.8. Using the summated measure, the three situations will produce the same overall score of EO. However, the three different EO configurations have disparate implications about how the entrepreneurial processes unfold and they lead to substantially different firm growth trajectories. The reason for the difference is that the three dimensions of EO do not contribute identically to firm growth. Although in this respect, studies under the multidimensional view of EO have examined the distinct effects of the three EO dimensions on firm performance, with findings revealing that the three EO dimensions usually have disparate effects on firm performance (Hughes and Morgan, 2007; Shan, Song and Ju, 2016). However, what goes unnoticed is that the joint effect of the three dimensions is not simply the sum up of the effects of the three individual dimensions. Whether based on the unidimensional view or the multidimensional view, there is no denying that there could be interaction effects among the three EO dimensions.

6.3.5. Towards a Configurational View of EO

There is some emerging research investigating how should firms configure the three dimensions of EO (Kreiser and Davis, 2010; Linton and Kask, 2017). For example, in Kreiser and Davis (2010, p. 49): "Thus, rather than seeking to have the highest level of EO, an organization should seek to find the most effective configuration of its innovative, proactive and risk-taking behaviour." However, the focus of present studies has been on how the three dimensions individually cater to different environmental conditions, while the interactions and synergies among the three dimensions have been overlooked.

6.3.5.1. The interaction between innovativeness and proactiveness

This study finds that the three dimensions of EO interact with each other in a complicated way. Firstly, the simulation shows that the thresholds of innovativeness that distinguish the different growth modes are dependent on how proactive the firm is. Specifically, the more proactive the firm is, the lower the thresholds in innovativeness that distinguish different growth modes. Likewise, the thresholds of proactiveness distinguishing the different growth modes are also dependent on how innovative the firm is and the more innovative the firm is, the lower the thresholds in proactiveness that distinguish different growth modes. These results are also found to hold under different conditions of risk-taking. The existence of this interaction effect is because both innovativeness and proactiveness contribute positively to the productive opportunity set of the firm. Therefore, they could act as substitutes to some extent.

Nevertheless, the simulation also shows that both innovativeness and proactiveness are necessary for entrepreneurial success, i.e. neither of them alone is sufficient for entrepreneurial success. This finding thus indicates that the relationship between innovativeness and proactiveness is neither purely substitutive nor purely complementary, but a mixture of the two. Existing literature has always indicated a closely related role between innovativeness and proactiveness. For example, in Lumpkin and Dess (1996, p. 148), "Because proactiveness suggests an emphasis on initiating activities, it is closely related to innovativeness and is likely to covary with it, as in the case of new-product introductions". Studies attempting to reconceptualise the EO construct also try to merge innovativeness and proactiveness into one dimension, as different from the dimension of risk-taking (Anderson et al., 2015, p. 1583):

> "…under the conceptual dndomain of entrepreneurial behaviours, innovativeness and proactiveness are inextricably confounded. This confounding leads to our second reason for collapsing innovativeness and proactiveness into a single dimension: while innovation is a necessary condition for entrepreneurship, it is not sufficient, nor is it meaningfully independent from proactiveness in this context (Rosenbusch, Brinckmann, Bausch, 2010). For example, as Schumpeter's classic works (1934, 1942) noted in their treatment of creative destruction, it is the combination of innovation (the creation of the new) with the process of commercialization (creating new markets and destroying old markets) that is the defining characteristic of entrepreneurship. The argument is that entrepreneurial firms do not simple create; entrepreneurial firms create with the intent of employing those creations to establish market leadership positions, to develop new markets and to pre-empt competitors (Schumpeter, 1942)."

What this study further suggests is that, after reaching some minimum thresholds, being simultaneously highly innovative and proactive seems not a good choice, as this will increase firms' chance of collapse. Both innovativeness and proactiveness contribute positively to firms' productive opportunity set, but one advantage of proactiveness over innovativeness is that the shortening innovation development time could reduce resource expenditure (Kessler and Chakrabarti, 1996; Stanko, Molina-Castillo and Munuera-Aleman, 2012). Consequently, in this study, it turns out that the best combination is high proactiveness and low innovativeness.

6.3.5.2. The intervention of risk-taking

This study finds that risk-taking could change the exponential growth and growth stagnation caused by innovativeness and proactiveness into collapse, but cannot turn the collapse or stagnation caused by innovativeness and proactiveness into high growth. What this suggests is that taking risks alone could not lead to firm growth. This result echoes with existing studies, which find that high risk-taking without innovativeness or proactiveness is detrimental for firm growth (Hughes and Morgan, 2007; Lomberg et al., 2016). Although risk-taking cannot lead to growth by itself, under certain conditions high risk-taking could increase the scale of growth achieved as a result of innovativeness and proactiveness and could sometimes prolong the survival time of the firm.

The interaction effect between innovativeness and proactiveness, i.e. their complementary and substitutive relation, is found to still hold under different conditions of risk-taking. However, this study finds that the more risks the firms take, the lower the thresholds of innovativeness and proactiveness upon which firm collapse turns from a probabilistic event to a definite event. This suggests that the exact thresholds in innovativeness and proactiveness upon which firm collapse becomes definite are not only interdependent but also dependent on how much risk the firm takes.

Furthermore, this study finds that moderate risk-taking and high risk-taking produce similar long term 95% firm growth landscape. Low risk-taking, in contrast, produces significantly overall higher growth than moderate and high risk-taking. Therefore, risk aversion is recommended for firms that aim to grow big. However, an additional finding on the effect of risk-taking is that, when risk-taking is low, a little bit increase in the degree of innovativeness could lead to dramatic increases in the probability of failure, far more than it causes when risk-taking is high. This additional finding reminds us that even low risk-taking is not really that safe. This finding seems to suggest that the effect of innovativeness on firm survival is influenced by how much risk the firm takes. The less the risk the firm takes, the bigger the impact of innovativeness on the likelihood of firm failure. Even though the simulation suggests that firms with low degrees of innovativeness and risk-taking, and high level of proactiveness have high growth potential, operating at this highest level of growth is very dangerous if firms are not aware of carefully controlling their degree of innovativeness.

Adopting a process approach, this study is set out to understand both the individual effect of the three EO dimensions and their joint effect on firm growth. The simulation results signal that firms need to adjust the other two dimensions simultaneously when changing one dimension of EO in order to attain desirable long-term growth outcomes. Because as firms become more and more proactive, the levels of innovativeness at which long-term high growth occurs fall down. In addition, as can be seen in the 3D figures, changing EO along one specific dimension usually only leads to a local peak in growth. The results seem consistent with neither the unidimensional view of EO, which argues that the three dimensions vary independently nor with the reflective view of EO, which implies that the three dimensions of EO change in the same direction.

There are studies employing the confirmatory factor analysis to examine the dimensionality of EO, with some findings suggesting that the three dimensions of EO are in fact independent (Stetz et al., 2000). While this suggests that in reality, the three dimensions of EO do sometimes vary independently, it does not mean that the three dimensions “should” vary independently for the sake of long-term growth (George., 2011). The implications these results, produced from a process perspective, have for the ongoing discussion regarding the dimensionality of EO is that, perhaps we should shift the theoretical question of “can the three dimensions vary independently” to the questions of “should the three dimensions vary independently?” and “how should the three dimensions vary? ”.

From a process perspective, this study specifies the role of the three dimensions in the entrepreneurial process individually and does not deliberately specify any interaction terms among the three dimensions as input into the model. The interactions among the three behavioural dimensions are caused by the fact that the entrepreneurial process is a complex system in which the different pieces of the process are interlinked with each other through various feedback loops. As these processes repeat themselves within firms, the effects of the different behavioural dimensions feedback into each other, giving rise to complicated interaction effects on firm growth.

The existence of interaction effects among the three dimensions suggests that noting the effects of the individual dimensions alone, as is usually done in the multidimensional view of EO, or noting the overall EO construct alone, as usually done in the unidimensional view of EO, are neither sufficient. Explaining the EO and firm growth relation from the configurational perspective requires understanding the mechanisms through which the different behavioural dimensions and processes interact with each other. EO is not only a matter of degree but also a matter of configuration. This may account for one of the potential reasons why empirical research on EO consistently shows mixing results. The existence of the interdependent effects among the three dimensions revealed in this study requires future research not only examining the level of overall EO but also taking the differences in its dimensional configurations into account.

Simulation analysis in this study further shows that actually, all the three EO dimensions relate to firm resource consumption directly or indirectly. In this sense, the three dimensions exist not only as complementary but also as competing relations. This provides one further rationale as to why firms need to configure and balance the three dimensions under resource constraints. The capabilities to configure the different behavioural dimensions of entrepreneurial process under resource constraints could help firms identify and exploit new entrepreneurial opportunities that give firms an advantage in growth. A theory of EO that takes into account the differences of firms in configuring the different behavioural dimensions of entrepreneurship might have more explanatory power for the heterogeneity in firm growth.

6.3.6. Theoretical Implications for the Risk-taking Dimension of EO

One important finding of this study is that the effect of risk-taking on firm growth is contingent on how proactive and innovative the firm is. Specifically, this study finds that the double-edged sword of risk-taking is reduced to only the damaging edge when the firms are growing at an extraordinary rate due to the combination of innovativeness and proactiveness.

Existing conceptualization of risk-taking has been focusing on describing the risk-return relation in a probabilistic way (Lumpkin and Dess, 1996). The most used conceptualization of risk-taking is that the more risk the firms take, the higher the potential of downside cost and the higher the variability in the potential payoff (Forlani and Mullins, 2000; Dencker and Gruber, 2014). Consistent with this conceptualization and recognizing the problem of survival bias in prior empirical studies of the EO—performance relation, the EO as experimentation view (Wiklund and Shepherd, 2011) has advanced our knowledge of EO by shifting from a traditional focus on its effect on mean performance to its effect on the variance of firm performance (Wales, 2015). In Wiklund and Shepherd (2011, p. 937), “We believe that our finding that EO seems to operate as a double-edged sword—it can enhance performance provided that a firm survives but also increases the probability of failure—is novel and important.”.

The simulations in this study indeed make this finding—high risk-taking increases the probability of firm failure while simultaneously enlarging the scale of growth for the surviving firms. In addition to that, this study unveils a new finding that the variance enhancing effect of risk-taking does not hold on all occasions. Extensive simulations show that high risk-taking will enlarge the variability in firm growth only when the firm's resource base is not depleted by innovative and proactive behaviour. Under the condition that firms are growing quickly as a result of innovation and proactivity, risk-aversion is a much better choice than risk-taking. The higher the growth produced by innovativeness and proactiveness, the more susceptible the firm is to risks. Depending on the degrees of proactiveness and innovativeness, any level of risk-taking, be it high, low, or moderate, could be the best choice for firm growth.

Two core processes contribute to this varying effect of risk-taking. One is that the random events brought about by risk-taking when coupled with the reinforcing firm growth loop creates the path dependence process in firm growth. The other part of the mechanism is that the massive resource consumption out of innovation and proactivity deprives firms' resource stock and increases firms' vulnerability to unexpected losses.

A common belief is that the negative effects of EO come from the dimension of risk-taking, while innovation and proactivity have generally been regarded as beneficial (Hughes and Morgan, 2007). Although this study finds the damaging side of risk-taking, it also shows that even in the absence of risk, excessive innovation and proactivity could also drive the firm into a vicious cycle of decline. Rather, although risk-taking could induce firm failure, it could also enlarge the scale of growth and sometimes prolong the survival time for firms that will eventually collapse out of innovativeness and proactiveness. Furthermore, this study finds that excessive innovation and proactivity make firms prone to unexpected losses and could reduce the double edge of risk-taking to be with only the damaging edge. Therefore, even risk-taking brings in the possibility of unexpected losses, it cannot take full responsibility for all the negative growth outcomes—the other two dimensions at least provide the context to change the way how risky events work.

A distinct character of risk-taking from that of innovativeness and proactiveness is that there is a subjective element in it. Risk does not present itself easily but needs to be perceived and assessed. People or organizations differ in their abilities to perceive and to assess risks. There are essential differences between risk-taking with accurate perception and understanding of the risks inherent and risk-taking with a blind eye or due to the inability to perceive the associated risk. Similarly, there is a fundamental difference between risk aversion as a result of an accurate assessment of the situation and risk-aversion merely because of the tendency to avoid risk on any occasion. In this respect, the literature has come up with concepts such as risk perception, risk assessment, risk propensity, in attempt to detangle or reconcile the subjective and objective aspects of risks (Sitkin and Pablo, 1992; Sitkin and Weingart, 1995; Forlani and Mullins, 2000). The EO literature, however, is surprisingly silent on this issue. Nevertheless, the existing conceptualization of risk-taking in EO literature seems to assume that firms are homogenous in their ability to perceive risks and that the perceived risk is well aligned with the true risk.

While simulations in this study suggest that risk aversion along with high proactiveness and low level of innovativeness produces the highest growth potential, attaining this status, i.e. making sure that the risk the firm takes is truly small, is not that easy. Conceptualizing risk-taking through quantification of the downside cost and potential returns is appealing, as resource losses may be the most intuitive and important consequences for risk-taking behaviour. However, risk-taking involves more than just being aware of the scale and probability of potential returns and losses. The entrepreneurs that have succeeded out of taking risks are those ones who are able to understand the sources and nature of the inherent risk and to seek alternatives when a crisis is about to happen (Drucker, 2014). This is why some successful entrepreneurs always say they do not view themselves as great risk-takers because of the way in which they perceive and assess risks (Busenitz, 1999).

In short, the simulation results in this study suggest that risk aversion is better than risk-taking when firms are growing quickly out of innovation and proactivity. The current conceptualization of risk-taking assumes that the perceived risk matches the true risk, but reaching this match is not easy.

6.3.7. Theoretical Implications for the Resource Based Theory

The resource-based theory (RBV) has been influential in both entrepreneurship and firm growth studies (Wiklund and Shepherd, 2003; Teng, 2007; Nason and Wiklund, 2015). It seeks to find the sources of firm heterogeneity from within the firm. The RBV based on Barney (1991) argues that firms are heterogeneous in terms of the resources they possess and that this heterogeneity could be long lasting due to the immobility of resources across firms. According to Barney (1991), resources differ in their value, rareness, imitability, and substitutability (VRIS), and only those firms in possession of VRIS resources could consistently grow quicker than others do. This resource-based theorizing is very powerful and scholars from a variety of disciplines have employed the RBV theorizing to identify the kinds of firm resources that qualify for the VRIS framework and thus lending firms superior performance (Crook et al., 2008). While the RBV has made a significant contribution to improving our understanding of a variety of phenomenon, it is subject to some questioning.

One of the key foundations of RBV is resource heterogeneity. A question arises is, where do these resources and their characteristics come from? Are the characteristics these different resources possess exogenously given, or put in another way, "inborn" with the resources? Are the values of the resources unchanging, and why? Another pivotal assumption underlying RBV is that resources are not uniformly distributed across firms. While this assumption holds in some cases, there are also many firms starting with identical resource endowments but end up in very different growth trajectories. The way through which this happens seems to be beyond the explanation of the RBV logic. Cannot the resources ordinarily accessible to firms afford firms advantage in growth? The role of human imagination and capability in making use of these resources seems to have been downplayed. In this regard, the Penrose theory of firm growth process (Penrose, 1959) makes the distinction between firm resources and the productive services the resources render. The productive services are a function of the way in which resources are used. While acknowledging the existence and importance of resource heterogeneity, the Penrose theory has an emphasis on the heterogeneity in firms' ability to recombine existing resources for new productive uses. In this sense, resource versatility could also play an important role in affecting firm growth—the same resource when employed differently could generate different productive uses. The value of resources, therefore, is not only determined by its own characteristics, but also by the firms' ability to "recognize" productive uses out of it.

The entrepreneurial discovery of new uses of resources and the entrepreneurial actions to recombine firm resources to take advantage of the opportunities play an important role in the Penrose theory. The field of entrepreneurship therefore presents as a challenge to the RBV view based on the VRIS framework. Realizing this contradiction, RBV scholars seek to resolve the conflicts between the two views by arguing that entrepreneurial recognition of new opportunities and entrepreneurial actions of resource recombination could also be considered as a kind of firm resources (Alvarez and Busenitz, 2001). The definition of firm resource in the Barney (1991, p. 101) is “all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm”. With this definition, basically anything that confers firm advantage has been and could be regarded as “firm resources” (Priem and Butler, 2001). This over-inclusive nature or use of the term “resources” and the infinite regress logic afford the resource-based theory immense explanatory power. But this vast explanatory power is only applicable to the “what” aspect, and this power comes at the cost of losing explanatory power in the “how” aspect of a theory.

Indeed, there are some EO studies contending that EO accords with the VRIS framework in RBV theory, therefore firms with EO are able to perform better than firms that do not possess EO (Lisboa, Skarmeas and Lages, 2011; Hong, Song and Yoo, 2013). It is true that EO could be argued to be valuable, rare, inimitable and non-substitutable, but the results from this study suggest that EO could not solely bring firms high growth without causing failure. The majority of theorizing in the management discipline seems to be in deterministic terms. The results signpost to RBV scholars that to accommodate RBV for theorizing in the entrepreneurial context, perhaps we need to reconsider the “dependent variables”, for example, to move away from the mean firm growth rate towards understanding the variance and distribution of firm growth.

Nevertheless, not all EO studies based on RBV argue in this way. The other EO studies instead make the argument that the effectiveness of EO on promoting firm growth depends on the availability of firm resources, as resources are indispensable to the entrepreneurial process (Wiklund and Shepherd, 2003; Anderson and Eshima, 2013). Admittedly, resource availability plays an important role in the entrepreneurial process, but this study suggests that EO also plays an important role in new resource generation. All the simulation runs in this study start with exactly the same resource condition, but they end up in different growth trajectories. One implication from this is that what matters sometimes is not how much resource in possession, but how to employ the entrepreneurial process to gradually build up firms’ resource base.

This study depicts the dynamic processes through which EO shapes firms' resource development path. Entrepreneurial activities and firm's resource stock interact and coevolve over time (Danneels, 2002). That is, a co-evolutionary perspective to look at the relation between entrepreneurship and firm resources. The dynamic and reciprocal relationship between EO and firm resource signals the need of a delicate balance between resource utilization and resource generation. An underutilized resource base will hinder the generation of new resources and firm growth, while an exhausted resource base makes growth unsustainable and constrains firms' capability to respond to crises. This finding is consistent with the resource slack theory that on one hand entrepreneurship enables firms to utilize slack resources for growth, on the other hand if resource slack is eliminated to a significantly low level, firms' ability to grow will be undermined (Nohria and Gulati, 1996).

This study also relates to another challenge facing RBV theorizing. That is, existing RBV literature has paid rare attention to the process through which resources lead to firm growth. As Priem and Butler (2001, p. 33) comment "The processes through which particular resources provide competitive advantage remain in a black box. We do not know, for example, how the resources generate sustainable rents, other than through their heterogeneity". This study constructs a process model of how firm resources are utilized and reproduced from an entrepreneurial perspective. Simulations in this study all start with the same resource condition, but depending on how these processes are conducted, firms end up in different growth trajectories.

This study therefore illustrates that it is not only the attributes of resources but also the developmental paths through which firms develop their idiosyncratic assets (Penrose, 1960; Alvarez and Busenitz, 2001). This reflects another fundamental difference between Penrose theory and the RBV theorizing based on Barney (1991). In the Barney theory, heterogeneity in firms derives from the characteristics of the resources, while in the Penrose theory, firm idiosyncrasy is created through a dynamic feedback process, where new resources are continuously generated during the expansion process, creating new productive opportunities and forming a unique productive opportunity set for each firm over time. This dynamic and path dependence process refutes the argument put forward by Barney that under the condition of homogeneous resources, any strategy that a firm could conceive of and implement could also be replicated by all the other firms.

6.4. Managerial Implications

The simulation results clearly signpost the importance of consistent innovation to get a steady stream of new products or services for the long-term sustained growth of the firm (Von Hippel, Thomke and Sonnack, 1999; Vagnani, 2015). Amounting evidence has shown that established firms that only focus on improving efficiency and reducing costs in existing products and processes will have stalled growth sooner or later (Kammerlander et al., 2015). Firms have to resist the temptation of focusing on the short term (Stevenson and Gumpert, 1985), and face up to the fact that all the existing products, services, technologies and processes that they rely on for revenue and survival are doomed to become obsolete in the future. The missed opportunities and organizational inertia caused by only sticking to familiar routines and procedures will render the firms victims to the Schumpeter creative destruction process (Schumpeter, 1942).

However, as prior studies have already suggested, excessive innovation could be destructive (March, 1991; Hyytinen, Pajarinen and Rouvinen, 2015). It is easy for firms to underestimate the delay and the uncertainty in the innovation payoff. The eroded resource base not only damages firms' ability to exploit existing innovations but also damages firms' capability to capture new opportunities (Dess and Lumpkin, 2005). Therefore, firms are advised to be selective on the projects they choose to engage with (Baker and Nelson, 2005) and be aware that exhausting their resource stocks runs the risk of being trapped in a vicious cycle of decline.

To achieve sustained growth in the long term, innovation alone is insufficient. Firms also need to be proactive at least to some extent in terms of new entry. An innovation that is too late to the market may not be an innovation any longer. Both innovativeness and proactiveness are necessary for entrepreneurship, but neither of them alone is sufficient (Shane and Venkataraman, 2000). Being the first to a new market or to introduce a new product has many benefits, such as occupying the superior market position, advantages in establishing customer base and shaping the industry standards of goods (Lieberman and Montgomery, 1998). Firms need to ensure that they are constantly scanning the environment to detect market changes, potential opportunities, as well as threats. Nevertheless, early entrants with innovative products are sometimes taken advantage by followers with strong marketing and manufacturing capabilities when the initial technological and market uncertainties are resolved.

This study suggests a complicated relationship between innovativeness, proactiveness, and firm growth. On one hand, for the pioneering strategy to be effective, firms need to possess at least some degree of innovative capability (Lieberman and Montgomery, 1998); On the other hand, innovation activities will lead to the consumption of scarce firm resources, which in turn affects the effectiveness of proactiveness. More intriguingly, as both innovativeness and proactiveness contribute positively to the productive opportunity set of the firm, this study also suggests the existence of substitutive effect between innovativeness and proactiveness. Although the complicated relationship poses challenges for firms to manage the entrepreneurial process, firms could take advantage of these interaction effects to achieve their growth goals. For example, firms disadvantaged in innovation capability could try to be more proactive in market entry, while firms having trouble in being proactive could leverage their innovation capability to achieve growth.

This study shows that how much risk to take depends not only on the ambition of the firm but also on how proactive and innovative the firm is. For firms with massive innovation commitment and a pioneering focus, taking high risk is not a good tactic. In such situations, being cautious about any potential risk and adopting a risk-aversion inclination will probably give rise to high growth in the long term. On the contrary, on the condition that innovativeness and proactiveness are controlled well, for firms that are ambitious to grow bigger than the competitors, high risk-taking may enable them to fulfill their ambition. To manage the duality of risk-taking, firms are advised not to underestimate the effects of small, insignificant events, as they may trigger the transition from virtuous growth to a vicious spiral of decline.

In particular, the existence of interaction effects among the three EO dimensions indicates that to employ EO for high long term growth requires considering more than an overall level of EO. The configurations of the three behavioural dimensions of EO must be taken into account. Firms need not be simultaneously highly innovative, proactive, and risk-taking to benefit from the entrepreneurial process (Zellweger and Sieger, 2012). Actually, the simulation results show that firms with extensive innovation commitments, being extremely proactive, and taking high risks are the ones that experience the worst growth. Firms need to understand not only how each dimension of EO influences firm growth individually, but also how the dimensions interact with each other in stimulating growth.

The existence of tipping point behaviour in firm growth not only cautions managers to be particularly prudent when engaging with entrepreneurial activities but also reminds managers to be aware of nonlinearity. It might be a human tendency to rely upon linear and deterministic reasoning in decision-making. However, this simplistic linear understanding is very risky if managers apply it in their learning process to look for the best dimensional configurations of EO. It is important for firms to move away from the linear stage model of the entrepreneurial process to practice system thinking of how these processes interact and unfold within firms.

Although this study finds that random events play an important role in the growth trajectories of the firm, it does not mean that firms could do nothing about it. Indeed, there are firms that do manage to survive crises, which could not be attributed purely to good luck. The existence of path dependence in firm growth, on one hand, informs firms to be cautious that insignificant events may lead to a downward spiral of firm decline, on the other hand, suggests that firms could take advantage of the reinforcing growth loop to build up its advantageous place in the market. In the early stage of firm growth, all paths seem likely. In this situation, firms could influence which path it sets foot on using the slightest effort. Once the firm starts to grow, the positive firm growth loop will enable it to grow more. The enhanced resource base will improve firms' ability to survive from unexpected crises in the future. This informs firms that they could take advantages of the contingencies at hand to shape their paths.

Although theoretically speaking, firms could choose to be innovative and proactive without taking any risk. Under the constantly changing and future-oriented entrepreneurial context, it is hard to find an opportunity free of risk. Empirically, a high level of innovation always comes together with high risk (Rosenbusch, Brinckmann and Bausch, 2011). Actually, risk and uncertainty are the preconditions for the existence of opportunity. Otherwise, opportunities could be easily discovered and quickly depleted. While information acquirement and detailed analysis could help reduce the risk involved, there is always a proportion of risk irremovable in the future-oriented entrepreneurial process (Penrose, 1959). Thus while this study provides a long term growth outcome landscape out of the different dimensional configurations of EO, it is important for practitioners to bear this empirical issue in mind.

Financing has been an issue concerning many entrepreneurial firms. This simulation model informs firms that it is not only how much resources they possess, but also the way in which the resources are used that matters. Entrepreneurship could be regarded as a means to make use of existing resources and to develop new resources. But having faith in the power of entrepreneurship and devoting massive resources into it is not enough. Firms should be aware that entrepreneurship is a process, a process that could be managed, and a process that should be diligently managed. It is the process through which the resources are made use of that creates the idiosyncratic asset of the firm. Firms need to keep the delicate balance between leveraging their existing resources and developing new ones.

This study has uncovered many insights on entrepreneurship within firms that might be helpful for firms to manage the entrepreneurial process. But when interpreting the findings, managers should be cautious of the boundary conditions of this model. For example, this study does not consider the effect of external funding acquisition. Therefore, the long time delay discovered in Figure 5.4, that it takes firms with increased entrepreneurial commitments a long time to outperform others may not apply to firms that have outside funding to support entrepreneurial activities. For firms that rely on internally generated funds to grow, they should be made aware that the substantial benefits of exponential growth more often reveal in the long term.

6.5. Limitations and Future Work Directions

This study is subject to some limitations that may inform future work. Firstly, the use of computational model enables this study to uncover the complex underlying processes and to unveil many novel insights that are beyond the traditionally used qualitative or quantitative methods in entrepreneurship studies. A major concern for simulation model is that it cannot resemble reality. The argument I want to make here is that actually no model is correct. This problem is not unique to the simulation model, but is also inherent in statistical and econometric models. Nevertheless, a model is not a full replication of reality does not mean it is useless. Model boundary should be evaluated for the satisfaction of the purpose of study. The pursuit of absolute replication of the real system will go into an unlimited huge model, which damages the analysis of the core mechanism. On the contrary, concise and elegant models could reveal intriguing new insights that improve our mental model. The model is useful if it could help us refine our mental model and improve our understanding and decision making process.

Secondly, scholars could explore the boundary conditions of the system behaviour. For example, this study only considers the funding generated from the firms' own internal development, while in reality firms could acquire funds from external partners, such as venture capitalists and banks. Scholars could include the external financing process into this model and explore the system behaviours. Similarly, scholars could also explore how the system behaves under different environmental conditions.

Thirdly, for the sake of simplicity, the model employs a static resource allocation function for exploration and exploitation activities. This static resource allocation function is simple and more realistic for managers to follow, but it might also be reasonable to think that entities are adaptive and new insights might be gained by trying more sophisticated learning rules and dynamic resource allocation functions.

Fourthly, so far qualitative research of EO has been rare. This study joins the consistent call for qualitative research in EO (Wales, 2015). The majority of extant entrepreneurial process models are built theoretically, with only a few built on empirical investigation (Moroz and Hindle, 2012). The model proposed in this study is theoretically derived from existing literature and case studies in entrepreneurship. The theory developed in this study through simulation provides as propositions that are subject to empirical validation. Additional insights might be gained from field studies that empirically capture how these entrepreneurial processes unfold within firms. Are the three dimensions of EO "able" to covary? In addition, is there any other organizational process intervening?

Fifthly, like many other studies, this study considers the existing conceptualization of risk-taking dimension of EO as relatively weak and calls for further effort in the theorizing of risk-taking in the entrepreneurial context.

Sixthly, that the entrepreneurial process consisting of entrepreneurial opportunity identification, evaluation, and exploitation has been acknowledged in the entrepreneurship literature. This study shows that some simple interactions among the sub-processes could create many counterintuitive insights. Thus for the entrepreneurship study, this study suggests that more attention could be paid to how the sub-processes of the entrepreneurial process interact and what implications they have.

Finally, this study has limitation in terms of the construct value and data sources. This is due to the challenge of finding studies and data that could well capture the construct of the entrepreneurial opportunity, as well as the challenge to obtain a single empirical dataset that is inclusive of all parameters in the model. Nevertheless, it is not rare for simulation studies to draw on data from a variety of sources. Appendix_2 has an expanded discussion on the model constructs and data sources.

6.6. Conclusion

Many firms fail to achieve their growth goals, even when they commit significant resources into entrepreneurial activities. The main aim of this study is to improve our understanding of how entrepreneurial processes unfold within firms and how these processes lead to firm growth. This study develops a process model of entrepreneurship within firms and finds that EO has important implications for firm growth. All three dimensions of EO exhibit important but disparate effect on firm growth in the long term. Interestingly, the simulations show the existence of better before worse and worse before better scenarios, as well as tipping point dynamics, indicating that the relationship between EO and firm growth cannot be understood using the traditional linear thinking.

Simulation analysis further reveals that the effects of the three dimensions of EO are inextricably linked through the feedback loops among the different pieces of the firm growth process. The three behavioural dimensions of EO interact with each other in a complicated way, and the effect of one dimension of EO on firm growth is dependent on the other two dimensions. Analysis of model structure and model behaviour reveals the underlying mechanism behind the individual effects as well as interaction effects among the three EO dimensions on firm growth.

Entrepreneurship scholars have largely adopted a linear assumption of stage model consisting of opportunity identification and exploitation in the understanding of entrepreneurial process, while overlooking how the subprocesses of entrepreneurial process interact and the implications of these interactions. This study hopes that examing EO beyond the traditional variance explanation and linear approach, towards incorporating process explanation and system thinking could inspire and inform future research on the entrepreneurial process. Future research could move towards a configurational view of EO that emphasizing the overall level of EO alone is insufficient and consideration needs to be paid to how the three dimensions of EO are configured in order to understand the true effect of EO in promoting firm growth. This further relates to the ongoing discussion on the dimensionality of EO: that perhaps we should shift from a question of whether the dimensions of EO vary independently to a question of whether the dimensions of EO should vary independently.

Appendix_1 Definitions of Model Constructs

Model constructs	Definitions
Entrepreneurial opportunity	Entrepreneurial opportunities are those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production (Shane and Venkataraman, 2000).
Productive opportunity set	The productive opportunity set is the accumulation of those identified opportunities that are under exploitation.
Opportunity identification rate	The rate at which firms identify and experiment with new entrepreneurial opportunities.
Innovation rate	The rate at which firms develop new products, services, or processes.
Required resource	The amount of resource required for exploration activity.
Cost per opportunity	The average amount of resource required per month for exploiting one entrepreneurial opportunity.
Resource availability	Resource availability is the ratio between the resources available for exploration activities and the resources required for exploration activities.
Normal innovation delay	The average duration of exploiting an entrepreneurial opportunity at the industry level.
Average innovation delay	Time elapsed from the moment when the exploitation starts to the moment when the opportunity is transformed into a concrete new product, process, or service that is ready for market introduction.
Opportunity abandon rate	The rate at which firms discontinue the exploitation of identified entrepreneurial opportunities.
Abandon fraction	The inverse of the length of time when the opportunity is an opportunity, which resonates with the concept of “opportunity window”.
Consumption by exploration	The amount of firm resource consumed by exploration activities.
Fraction for exploration	The fraction of firm resource devoted for exploration activities.
Resource stock	The firm’s totally accumulated resources.
Consumption by exploitation	The amount of firm resource consumed by exploitation activities.

Profit margin	Profit margin represents the percent of firm sales that has turned into profits.
Sales rate	The rate at which firms sell their products or services.
Production rate	The rate at which firms produce their products or services.
Inventory	The units of products or services firms have in stock.
Cost per unit	The average amount of resource required to produce one unit of product or service.
Desired resource for exploitation	The amount of resource desired for exploitation activities at a given time.
Sales per innovation	The average units of sales that each exploited opportunity, i.e. innovation, could create.
Potential sales rate	The total units of sales created by the firm's innovation stock.
Innovations stock	The stock of exploited opportunities, i.e. innovations, that are valid for creating market demand for the firm.
Innovation decay rate	The rate at which existing innovations cease to be innovation, i.e. lose the power of creating market demand for the firm.
Average innovation life	The length of time when an innovation is an innovation, which resonates with the concept of "product life cycle".

Appendix_2 Overview of Model Parameters

Parameter	Value	Unit	Data source
Profit margin	0.088	dimensionless	China Statistical Yearbook 2017
Normal cost per opportunity	63.57	thousand dollars per month per opportunity	China Statistical Yearbook 2017
Mean	8.02	dimensionless	China Statistical Yearbook 2017
Cost per unit	0.27	thousand dollars per unit	Calculated from the average smartphone price per unit in China in 2016, data from GfK.com, in Statista
Normal innovation delay	15	month	Marion et al. (2015)
Average innovation life	24	month	Van Oorschot, Langerak and Sengupta (2011)
Fraction for exploration	0.1	1/month	Ho, Tjahjapranata and Yap (2006)
Delivery delay	0.5	month	Nominal value based on life experience
Abandon fraction	1/15	1/month	Equal to the inverse of the normal innovation delay
Smoothing time	15	month	Equal to the normal innovation delay
Correlation time	24	month	Equal to the average innovation life
DT	0.015625	month	The simulation time step

The China Statistical Yearbook contains information on the number of new products developed, the expenditure on new products development, and the sales from the new products, of the electronics and communications sector of China high tech industry. These are sector aggregated data. Some basic arithmetic transformations were made to the original data to inform the parameters in the current model:

Normal cost per opportunity = expenditure on new products development/(the number of new products developed*12*exchange rate between dollar and RMB).

Mean = log transformation of (sales from new products/(the number of new products/(12*exchange rate between dollar and RMB))).

Profit margin = sales from new products/manufacturing costs - 1

Cost per unit = average smartphone price in China/(1+profit margin)

Van Oorschot, Langerak and Sengupta (2011) use the system dynamics method to examine the new product development process. Most exogenous variables in this study come from the survey of 72 manufacurers of industrial products in Netherlands in Langerak, Hultink and Griffin (2008).

Marion et al. (2015) conduct a longitudinal ethnographic study of the new product development process of 14 ventures. The two ventures in the consumer electronics sector have an average new product development time of 15 months.

The parameter “fraction for exploration” means the percent of firm resources committed into exploration activities. According to Ho, Tjahjapranata and Yap (2006), the ratio between R&D expenditure and the book value of firm total assets of US companies between 1980 and 1998 is 0.1.

Correlation time: the pink noise structure is to generate a random number series with autocorrelation. As the average innovation life is 24 months, the correlation time is set to 24 months.

Smoothing time: the use of smooth function is to ensure that the payoff from the entrepreneurial process does not change immediately with the change in risk-taking, because opportunity exploitation process takes time. The smoothing time is set to equal to the normal innovation delay.

Abandon fraction: the opportunity abandon fraction is 1/15 per month, which means the opportunities have an average window of 15 months, equal to the normal innovation delay. This is to ensure that the opportunity is valid during the course of the opportunity exploitation process with industry level normal innovation delay.

As can be seen, the key model paramssters are informed by dataset and studies on new product development, while the entrepreneurial opportunity is not restricted to new products. However, according to the China Statistical Yearbook 2017, new product refers to "products developed and produced with new technologies and designs or improved in structure, material, process or other aspects so that their performance are improved or their functions expanded." This definition actually includes the other aspects, such as new processes.

Similarly, the definition of new product adopted in Marion et al. (2015) is "New product development–or the process and activities that firms undertake in conceptualizing, designing, testing, and commercializing a product or service for a market opportunity – is a fundamental entrepreneurial activity…". We could see that this definition does not exclusively refer to new "products" either.

I have been trying to find a single dataset that could be informative of all parameters in the model, but to no avail. The integration of model parameters from different sources, however, is not rare. For example, the parameter values in Van Oorschot, Langerak and Sengupta (2011) come from different literature as well as from empirical dataset.

Appendix_3 List of Model Equations

1 Opportunity abandon rate= productive opportunity set*abandon fraction
Units: opportunity/month

2 Average innovation delay= normal innovation delay*(1/resource availability)*(1.5- proactiveness) Units: Month

3 Change in pink noise= (white noise-pink noise)/correlation time
Units: 1/month

4 Cost per opportunity= normal cost per opportunity*(1+0.5*risktaking)
Units: tdollar/opportunity/month

5 Desired resource for exploitation= potential sales rate*cost per unit
Units: tdollar/month

6 Consumption by exploitation = MIN(resource stock*(1-exploration fraction), desired resource for exploitation) Units: tdollar/month

7 Consumption by exploration = MIN(resource stock*exploration fraction, required resource) Units: tdollar/month

8 Opportunity identification rate= productive opportunity set*(2^0.5*2^innovativeness)/average innovation delay Units: opportunity/month

9 Innovation decay rate= innovations stock/average innovation life
Units: opportunity/month

10 Innovation rate= productive opportunity set/average innovation delay
Units: opportunity/month

11 Innovations stock= INTEG (innovation rate-innovation decay rate)
Units: opportunity

12 Inventory= INTEG (production rate-sales rate)
Units: unit

13 Pink noise= INTEG (change in pink noise)
Units: Dmnl

14 Potential sales rate= innovations stock*sales per innovation
Units: unit/month

15 Production rate= consumption by exploitation/cost per unit
Units: unit/month

16 Productive opportunity set= INTEG (opportunity identification rate–opportunity abandon rate-innovation rate) Units: opportunity

17 Required resource for exploration= cost per opportunity*productive opportunity set Units: tdollar/month

18 Resource availability= consumption by exploration/required resource by exploration Units: Dmnl

19 Resource stock= INTEG (revenue–consumption by exploitation–consumption by exploration) Units: tdollar

20 Revenue= sales rate*cost per unit*(1+profit margin)
Units: tdollar/month

21 Sales per innovation= EXP(pink noise)
Units: unit/opportunity/month

22 Sales rate= MIN(potential sales rate, inventory/delivery delay)
Units: unit/month

23 Smoothed risktaking= SMOOTH(risktaking, smoothing time)
Units: Dmnl

24 White noise=mean + (((smoothed risktaking^2)*(2-(DT/correlation time)) / (DT/correlation time))^0.5) * RANDOM NORMAL(-10, 10 , 0 , 1 , noise seed)
Units: Dmnl

*tdollar here is the abbreviation of thousand dollar.

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